HUC 11070208 – Elk River
Water body IDs: 3259/3260/3263
303(d) Listing: *Escherichia coli*

Total Maximum Daily Load

for

North, Middle, and South Indian Creeks
Newton and McDonald Counties

303(d) Listing: *Escherichia coli* Bacteria

Submitted: March 3, 2021
Approved: May 12, 2021

Prepared by: Water Protection Program, Watershed Protection Section

WATER BODY SUMMARY
Total Maximum Daily Loads (TMDL) for North, Middle, and South Indian Creeks
303(d) Listing: *Escherichia coli (E. coli)* Bacteria

Waterbody	TMDL Development Priority
North Indian Creek	Medium
Middle Indian Creek	High
South Indian Creek	High


Location of watershed in Missouri

Location: Newton and McDonald counties

8-digit Hydrologic Unit Code (HUC):[1]
11070208 – Elk River

12-digit HUC Subwatersheds
110702080301 – North Indian Creek
110702080302 – South Indian Creek

Water Body Identifications (WBIDs) and Hydrologic Class:[2]
3260/3263/3259 - Class P

Designated Uses:[3]
Irrigation
Livestock and wildlife protection
Human health protection
Warm water habitat (aquatic life)
Cold water habitat (WBID 3259 only)
Whole body contact recreation category B
Secondary contact recreation

Impaired Use:
Whole body contact recreation category B

Pollutant Identified on the 2020 303(d) List:
Escherichia coli (E. coli) (fecal indicator bacteria)

Identified Sources on the 2020 303(d) List:
Rural nonpoint sources

Length and Location of Impaired Segments:
North Indian Creek (WBID 3260): 5.2 miles, from Section 24, Township 24N, Range 31W to Section 36, Township 25N, Range 30W
Middle Indian Creek (WBID 3263): 2.2 miles, from mouth to Section 16, Township 24N, Range 30W
South Indian Creek (WBID 3259): 8.7 miles, from mouth to Section 1, Township 23N, Range 30W

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[1] Watersheds are delineated by the U.S. Geological Survey using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS 2019). A hydrologic unit is a drainage area delineated to nest in a multilevel, hierarchical drainage system. A hydrologic unit code is the numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy (FGDC 2003).

[2] For hydrologic classes see 10 CSR 20-7.031(1)(F). Class P streams maintain permanent flow even in drought periods.

[3] For designated uses see 10 CSR 20-7.031(1)(C) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(E).

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1. Introduction

In accordance with Section 303(d) of the federal Clean Water Act, the Missouri Department of Natural Resources is establishing total maximum daily loads (TMDLs) to address elevated concentrations of *Escherichia coli* (*E. coli*) bacteria in North, Middle, and South Indian Creeks in Newton and McDonald Counties. This TMDL report addresses three water quality limited segments that are on Missouri's 2020 303(d) List of Impaired Waters due to exceedances of Missouri's *E. coli* bacteria concentration criterion.[4] These listings were approved by the U.S. Environmental Protection Agency (EPA) on November 30, 2020.[5] North, Middle, and South Indian Creeks are also included in the nutrient TMDL for the Elk River Basin, which was approved by EPA on March 26, 2004.[6]

Section 303(d) of the federal Clean Water Act and Title 40 of the Code of Federal Regulations (CFR) Part 130 require states to develop TMDLs for waters that do not meet applicable water quality standards. Missouri's Water Quality Standards at Title 10 of the Code of State Regulations (CSR) Division 20 Chapter 7, Rule .031 consist of three major components: designated uses, water quality criteria to protect those uses, and an antidegradation policy. A TMDL is equal to the loading capacity of a water body for a specific pollutant and represents the maximum amount of a pollutant that a water body can assimilate and still attain and maintain water quality standards. The *E. coli* bacteria loading capacities for each water body are derived from the maximum *E. coli* concentration allowed by Missouri's Water Quality Standards and are translated to mass loads using stream flow under all recorded conditions. Once the loading capacity of a water body has been quantified, existing and future point sources and nonpoint sources are assessed for their potential to contribute the pollutants of concern. In accordance with 40 CFR 130.2, contributing point sources are assigned a portion of the available loading capacity as a wasteload allocation and nonpoint sources are assigned a load allocation. In accordance with federal Clean Water Act section 303(d)(1)(C), a margin of safety is also included. Margins of safety can be explicit (numeric) or implicit (qualitative) to account for any lack of knowledge concerning the relationship between pollutant loading and water quality, uncertainty associated with the model assumptions, or data inadequacies (40 CFR 130.7). The TMDL for each pollutant is the sum of the wasteload allocation, the load allocation, and the margin of safety.

2. Watershed Description

North, Middle, and South Indian Creeks are located in southwest Missouri within the Elk River subbasin, which is cataloged by the U.S. Geological Survey (USGS) as the 8-digit hydrologic unit code (HUC) 11070208. Within this subbasin, the area of North Indian Creek 12-digit HUC watershed (110702080301) is 48.0 square miles and the South Indian Creek 12-digit HUC watershed (110702080302) is 48.7 square miles. Within the North Indian Creek watershed, the area of the Middle Indian Creek watershed is 22.5 square miles. North Indian Creek (WBID 3260) originates in southeastern Newton County and flows south for 5.2 miles to Indian Creek (WBID 3256). Middle Indian Creek (WBID 3263) is a tributary to North Indian Creek and extends 2.2 miles upstream from their confluence. South Indian Creek (WBID 3259) originates in northeastern McDonald County and flows northwest to Indian Creek. North and South Indian Creeks converge at their confluence with Indian Creek (Figure 1).

[4] A water quality limited segment is any segment where it is known that water quality does not meet applicable water quality standards, or is not expected to meet applicable water quality standards, even after the application of the technology-based effluent limitations required by sections 301(b) and 306 of the federal Clean Water Act (40 CFR 130.2).

[5] The Department maintains current and past 303(d) lists and corresponding assessment worksheets online at dnr.mo.gov/env/wpp/waterquality/303d/303d.htm.

[6] The Elk River TMDL can be accessed at: dnr.mo.gov/env/wpp/tmdl/docs/3246-elk-r-tmdl.pdf

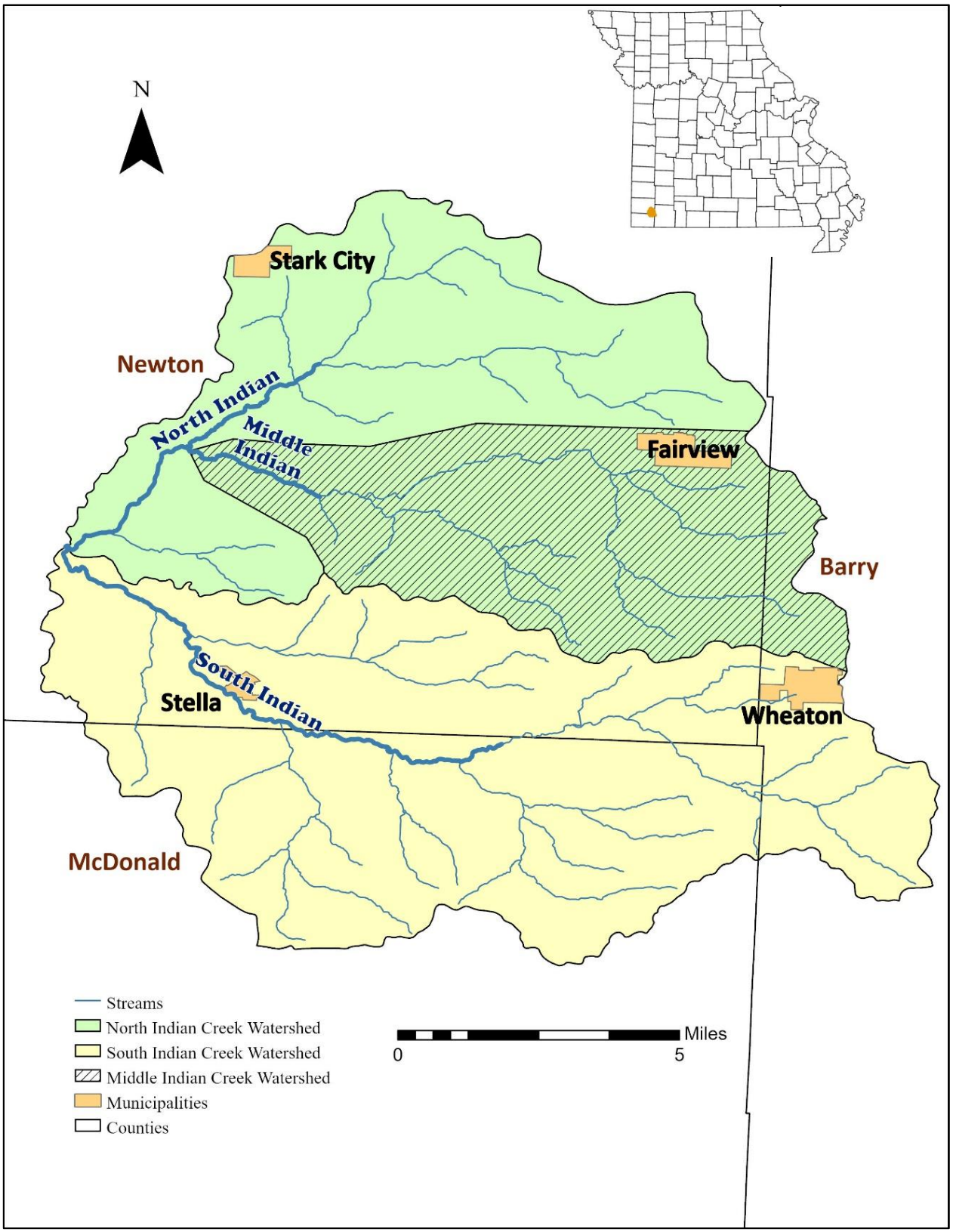

Figure 1. North, Middle, and South Indian Creek Watersheds

2.1 Geology, Physiography, and Soils

North, Middle, and South Indian Creeks are located within the Neosho ecological drainage unit, which straddles portions of four states: southwestern Missouri, southeastern Kansas, northeastern Oklahoma, and northwestern Arkansas (MoRAP 2005). Ecological drainage units are groups of watersheds that have similar biota, geography, and climate characteristics (USGS 2009). Within the Neosho ecological drainage unit, the North Indian Creek watershed is located in the Springfield Plateau EPA Level IV ecoregion (ecological subsection). The South Indian Creek watershed straddles the Springfield Plateau and Elk River Hills Level IV ecoregions. Ecoregions are areas with similar ecosystems and environmental resources and are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing spatial differences in ecosystems, ecoregions stratify the environment by its probable response to disturbance (Chapman et al. 2002). Ecoregions are defined in Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(H).

Like most streams in the Ozark Plateau subregion, streams in the Springfield Plateau and Elk River Hills Level IV ecoregions occupy narrow valleys separated by steep narrow ridges with clear water, high base flows, and low suspended sediment loads. Streambeds consist mainly of chert gravel and cobble. Well-defined riffles, gravel bars, and bluff pools are prevalent. Extensive stretches of bedrock channels are also present. Cliffs and streamside bluffs are common. Steep slopes combined with moderate to slow soil infiltration rates result in frequent flash-flooding during and after intense rainfall events (MoRAP 2005). The Springfield Plateau and Elk River Hills Level IV ecoregions are underlain by limestone formations. Surface waters are influenced by groundwater from the many springs. There are also numerous losing streams that drain to the subsurface. Geographic Information System (GIS) analysis of the North and South Indian Creek watersheds identified six springs in the North Indian Creek watershed, including two springs located in the Middle Indian Creek watershed, and seven springs in the South Indian Creek watershed. There are numerous streams that receive water from the subsurface (gaining streams) in the two 12-digit HUC watersheds.

The North, Middle, and South Indian Creek watersheds are comprised of approximately 40 individual soil types (NRCS 2011).[7] Soils are categorized into hydrologic soil groups based on similar runoff potentials. Each hydrologic soil group indicates the rate at which water enters the soil profile under conditions of a bare, thoroughly wetted soil surface (NRCS 2009). This infiltration rate determines the quantity of precipitation that flows over land to water bodies as direct runoff. Group A soils have the highest rate of infiltration and the lowest runoff potential. Group D soils have the lowest rate of infiltration and highest runoff potential. Many wet soils fall into dual soil groups (e.g., Group C/D) due to the presence of a seasonal high water table that results in saturation to the soil surface. Dual hydrologic soil groups account for this condition by providing both the drained and undrained condition of the soil.[8] It should be noted that soil runoff potential is only one factor that determines the volume of runoff in a watershed. Impervious surfaces, vegetative cover, slope, rainfall intensity, and land use can significantly influence the potential for runoff regardless of the characteristics of the underlying soil. Figure 2 shows the distribution of hydrologic soil groups and karst features in the North and South Indian Creek watersheds. Table 1 provides a summary of the hydrologic soil groups by area in square miles and relative percent.

[7] https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

[8] For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 24 inches (60 centimeters) below the surface in a soil where it would be higher in a natural state (NRCS 2009).

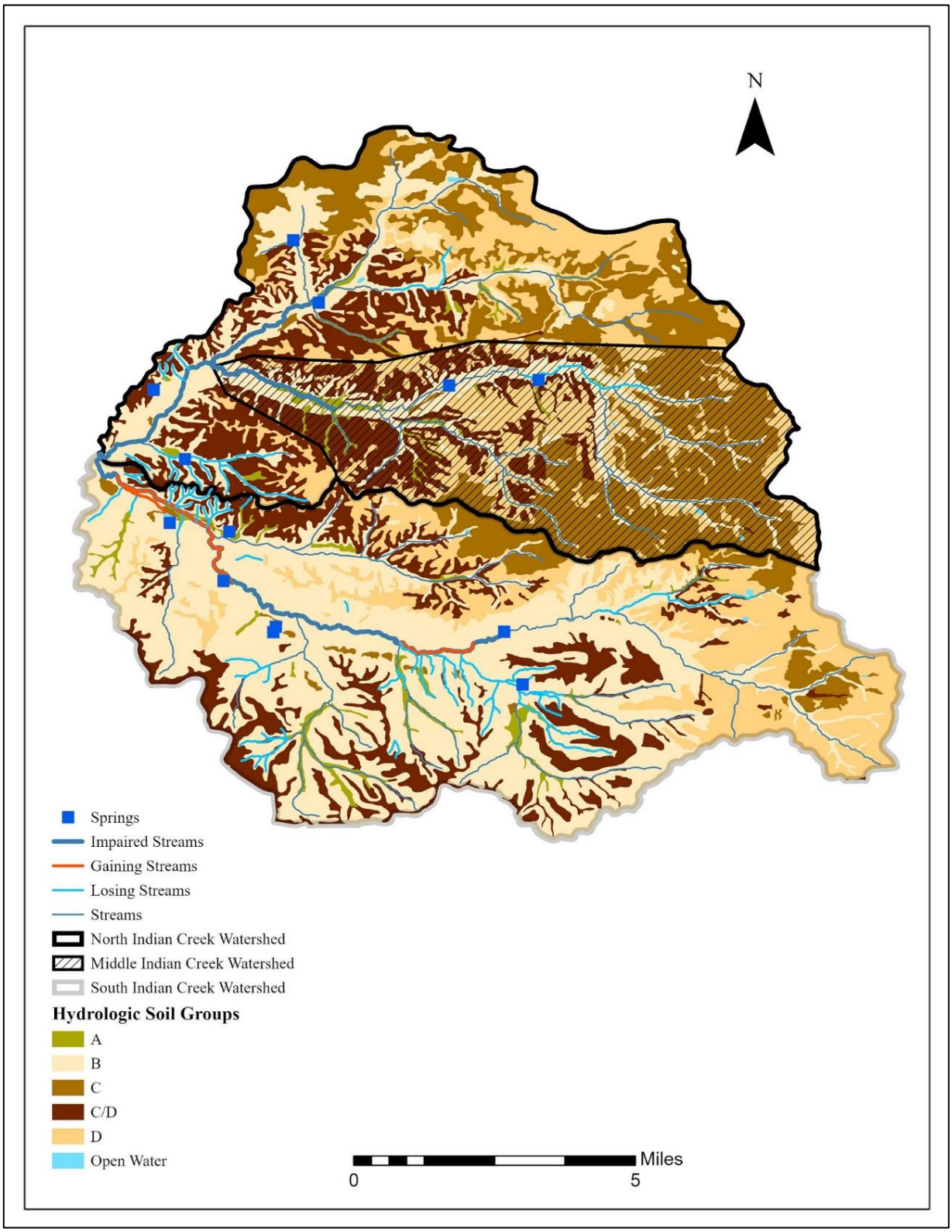

Figure 2. Hydrologic Soil Groups and Karst Features in the North, Middle, and South Indian Creek Watersheds

Table 1. Hydrologic Soil Groups in the North, Middle, and South Indian Creek Watersheds

Hydrologic Soil Group	Area in the Watershed	
	Square miles	Percent
North Indian Creek		
Group A	0.96	2.0%
Group B	10.11	21.1%
Group C	14.85	30.9%
Dual Group C/D	10.49	21.9%
Group D	11.54	24.0%
Open Water	0.05	0.1%
Total	48.00	100.0%
Middle Indian Creek		
Group A	0.54	2.4%
Group B	3.68	16.4%
Group C	8.10	36.1%
Dual Group C/D	4.84	21.6%
Group D	5.25	23.4%
Open Water	0.03	0.1%
Total	22.44	100.0%
South Indian Creek		
Group A	1.44	3.0%
Group B	26.90	55.2%
Group C	2.72	5.6%
Dual Group C/D	8.07	16.6%
Group D	9.49	19.5%
Open Water	0.07	0.1%
Total	48.69	100.0%

2.2 Climate

The most recent climate data from a weather station in close proximity to the North, Middle, and South Indian Creek watersheds were measured at the National Centers for Environmental Information Neosho Weather Station (USC00235976) in Newton County. The climate normals were developed based on temperature and precipitation data collected at that station between 1981 and 2010 (NOAA 2010). Precipitation normals are especially important because they relate to stream flow and runoff events that influence pollutant loading. Table 2 presents the 30-year monthly climate normals from the Neosho Weather Station for precipitation and temperature. Figures 3 and 4 further summarize these data.

Table 2. 30-year Monthly Climate Normals at the Neosho Weather Station

Month	Precipitation Total	Minimum Temperature	Maximum Temperature
	in	ºF	ºF
January	2.24	22.0	44.0
February	2.43	25.8	49.2
March	3.75	34.9	58.5
April	4.65	44.0	68.3
May	5.98	54.0	76.0
June	5.57	62.5	83.4
July	3.68	67.0	88.2
August	3.29	65.5	88.8
September	5.12	56.3	80.6
October	4.05	44.9	70.0
November	4.06	35.0	57.7
December	2.91	24.4	46.2
	Total	**Average**	**Average**
	47.73	44.7	67.6

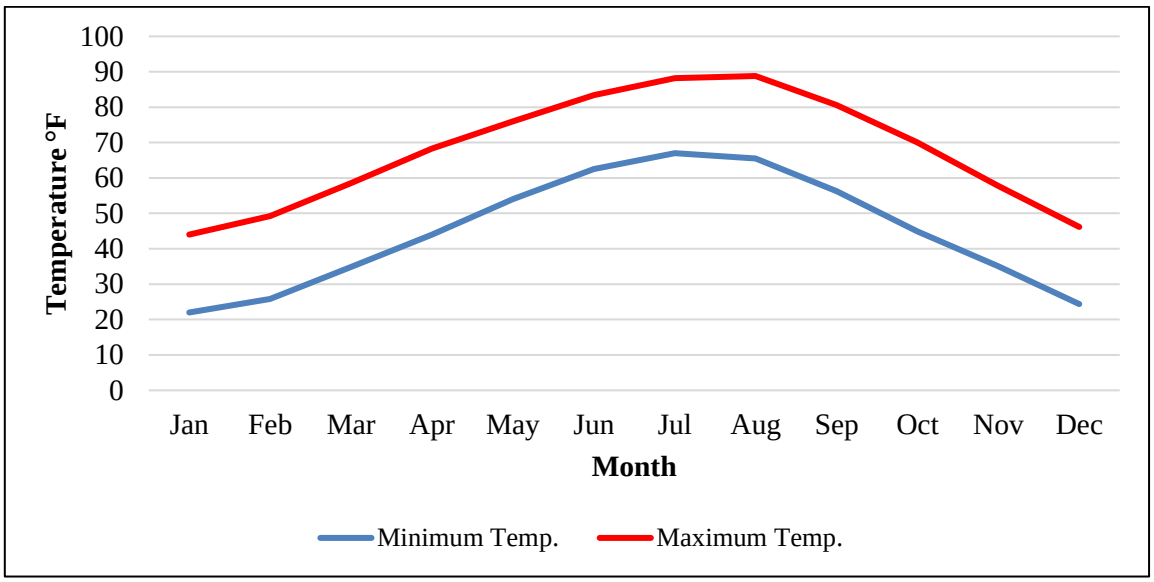

Figure 3. Monthly Minimum and Maximum Temperature Normals – Neosho, MO

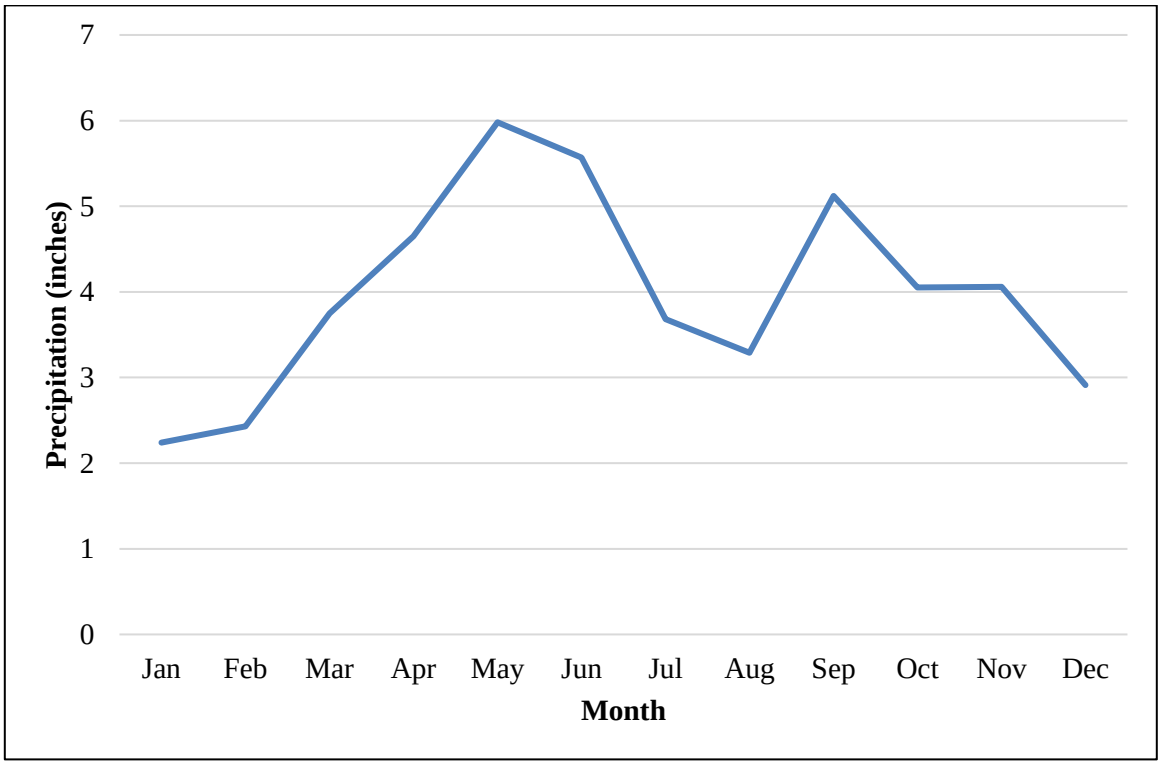

Figure 4. Monthly Precipitation Normals – Neosho, MO

2.3 Population

State and county population estimates are available from the U.S. Census Bureau's 2010 census and can be localized using census block data (U.S. Census Bureau 2010). Population estimates for the North, Middle, and South Indian Creek watersheds were derived using GIS software by overlaying the watershed boundaries over a map of census blocks (Figure 5). Wherever the centroid of a census block fell within a watershed boundary, the entire population of the census block was included in the total. If the centroid of the census block was outside the boundary, the population of the entire block was excluded. The municipal population was estimated using a similar method whereby municipal areas where overlain on the map of census blocks. The rural population was calculated as the difference between the municipal population and the total population.

As shown in Table 3, the populations in the North, Middle, and South Indian Creek watersheds have increased since 1990. At the time of the 2010 census, the U.S. Census Bureau did not officially designate urban areas in the watersheds. Urban area designation is one criterion used to determine whether a municipality is subject to municipal separate storm sewer system (MS4) regulations. None of the municipalities in the North, Middle, or South Indian Creek watersheds are subject to MS4 regulations.

Table 3. Population Estimates for the North, Middle, and South Indian Creek Watersheds

Municipal			Rural			Total		
1990	**2000**	**2010**	**1990**	**2000**	**2010**	**1990**	**2000**	**2010**
North Indian Creek								
451	561	550	912	1,033	1,155	1,363	1,594	1,705
Middle Indian Creek								
319	399	411	527	616	732	846	1,015	1,143
South Indian Creek								
764	897	854	1,090	1,360	1,306	1,854	2,257	2,160

EPA completed a demographic analysis in 2014 to identify areas where environmental justice may be of concern. EPA used demographic information from census block data on a 12-digit HUC scale and a web-based tool called EJSCREEN to determine areas that have potential environmental justice concerns. EPA defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (USEPA 2014a). Communities determined to have environmental justice concerns may qualify for financial and strategic assistance for addressing environmental and public health issues. The EPA analysis determined that the two 12-digit HUC watersheds, North and South Indian Creek, have potential environmental justice concerns as presented in Table 4.

Table 4. 12-Digit HUCs with Environmental Justice Concerns

12 Digit HUC	Percent of HUC cover by potential EJ block groups
110702080301 – North Indian Creek	50-70%
110702080302 – South Indian Creek	30-50%

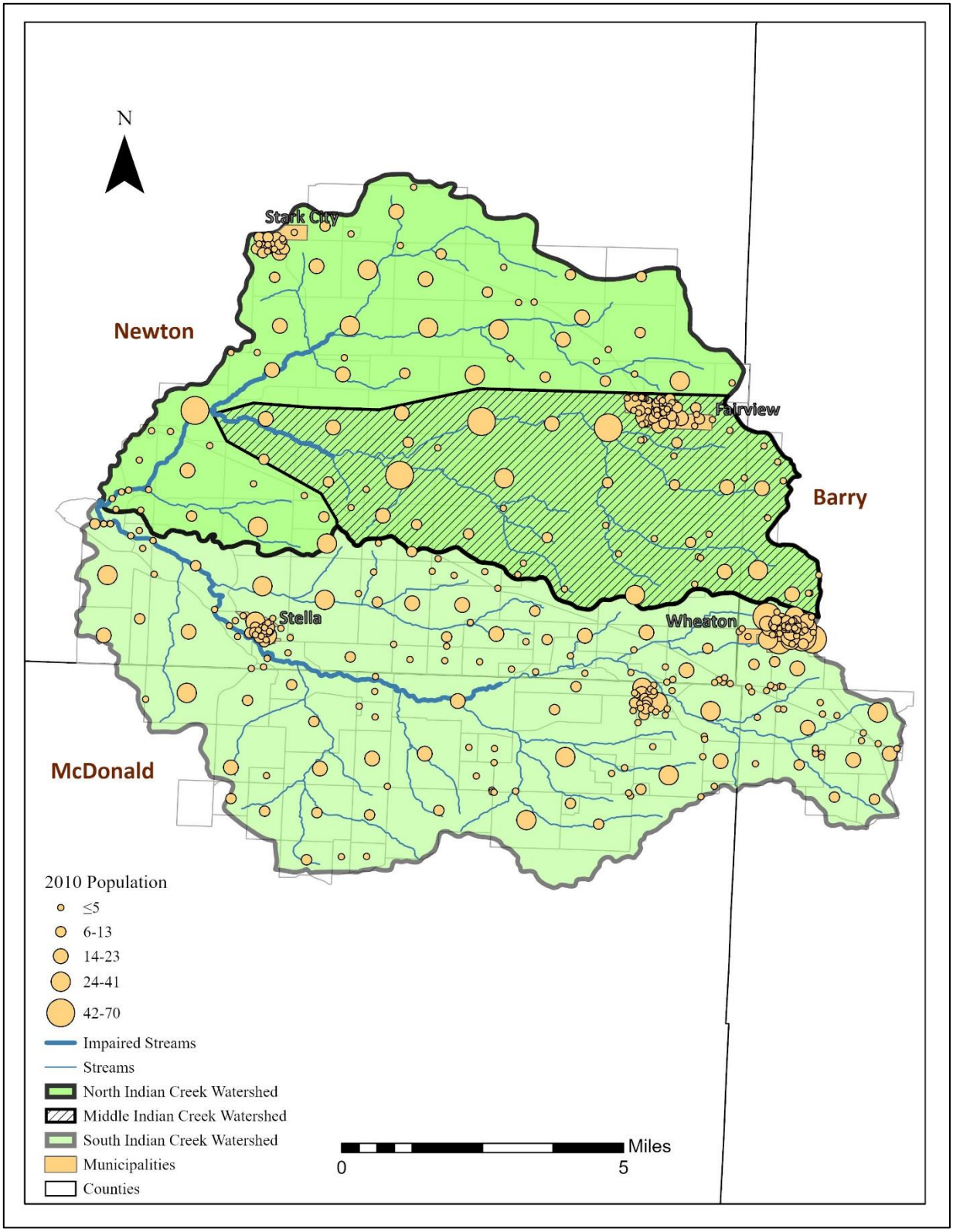

Figure 5. 2010 Population in the North, Middle, and South Indian Creek Watersheds

2.4 Land Cover

A land cover analysis was completed using the 2011 National Land Cover Database published by USGS (Homer et al. 2015). Land cover types present in the North, Middle, and South Indian Creek watersheds are summarized in Tables 5, 6, and 7. Figure 6 depicts the distribution of the land cover types throughout the watershed. Grassland and pasture areas potentially used for livestock grazing cover the majority of all three watersheds.

Table 5. Land Cover in the North Indian Creek Watershed

Land Cover Type	Area Square miles	Percent
Developed, High Intensity	0.03	0.06%
Developed, Medium Intensity	0.28	0.57%
Developed, Low Intensity	0.34	0.71%
Developed, Open Space	2.13	4.43%
Barren Land	0.03	0.06%
Cultivated Crops	4.16	8.67%
Grassland and Pasture	34.39	71.63%
Shrub and Herbaceous	0.33	0.68%
Forest	6.25	13.02%
Wetlands	0.06	0.13%
Open Water	0.01	0.03%
Totals	48.01	100.00%

Table 6. Land Cover in the Middle Indian Creek Watershed

Land Cover Type	Area Square miles	Percent
Developed, High Intensity	0.02	0.07%
Developed, Medium Intensity	0.14	0.62%
Developed, Low Intensity	0.14	0.61%
Developed, Open Space	1.02	4.56%
Barren Land	0.01	0.05%
Cultivated Crops	1.27	5.65%
Grassland and Pasture	17.01	75.78%
Shrub and Herbaceous	0.22	0.97%
Forest	2.59	11.53%
Wetlands	0.02	0.10%
Open Water	0.01	0.06%
Totals	22.44	100.00%

Table 7. Land Cover in the South Indian Creek Watershed

Land Cover Type	Area Square miles	Percent
Developed, High Intensity	0.034	0.07%
Developed, Medium Intensity	0.334	0.69%
Developed, Low Intensity	0.318	0.65%
Developed, Open Space	2.604	5.35%
Barren Land	0.003	0.01%
Cultivated Crops	0.697	1.43%
Grassland and Pasture	38.714	79.52%
Shrub and Herbaceous	0.092	0.19%
Forest	5.694	11.69%
Wetlands	0.166	0.34%
Open Water	0.031	0.06%
Totals	48.69	100.00%

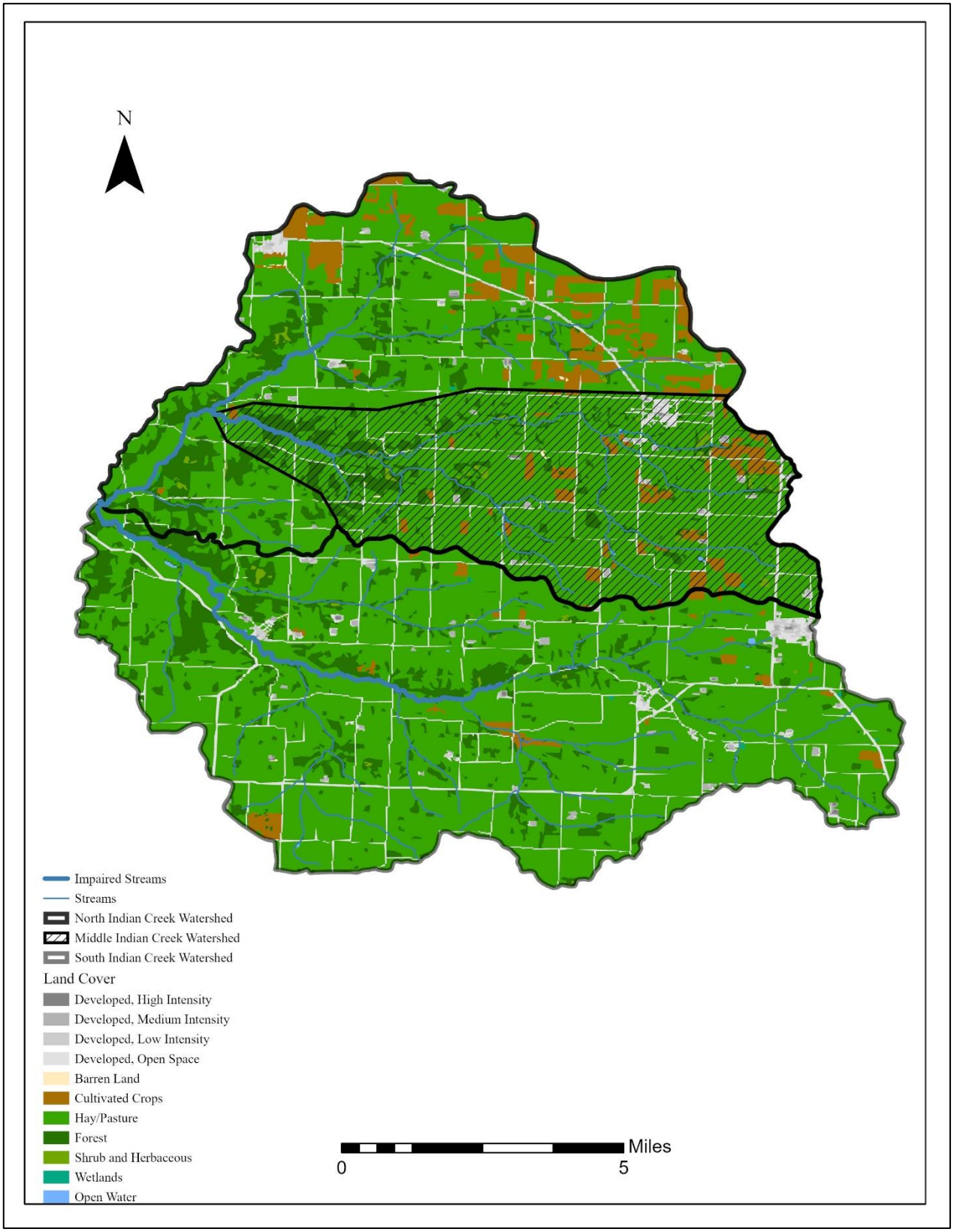

Figure 6. Land Cover in North, Middle, and South Indian Creek Watersheds

3. Applicable Water Quality Standards

TMDLs identify the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. Water quality standards are therefore central to the TMDL development process. Under the federal Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters (U.S. Code Title 33, Chapter 26, Subchapter III). Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy. In accordance with federal regulations at 40 CFR 131.10, Missouri's Water Quality Standards for each individual water body also provide for the attainment and maintenance of water quality in any downstream waters. Revising existing water quality standards is not within the purview of TMDL development. If future water quality monitoring demonstrates that existing water quality standards are not protective of individual water bodies or downstream uses, new water quality standards can be proposed in accordance with the guidance provided in EPA's Water Quality Standards Handbook.[9]

3.1 Designated Uses

Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(C) defines designated uses that are assigned to individual water bodies in accordance with 10 CSR 20-7.031(2) and are listed in 10 CSR 20-7.031, Table G (Lakes) and Table H (Streams). Missouri's Water Quality Standards designate the following uses of North, Middle, and South Indian Creeks:

- Irrigation;
- Livestock and wildlife protection;
- Human health protection;
- Warm water habitat (aquatic life);
- Cold water habitat (WBID 3259 only)
- Whole body contact recreation category B; and
- Secondary contact recreation.

The whole body contact recreation category B designated uses of North, Middle, and South Indian Creeks are impaired due to high *E. coli* bacteria concentrations. Whole body contact recreation includes activities that involve direct human contact with waters of the state to the point of complete body submergence (10 CFR 20-7.031(1)(C)2.A.). During whole body contact activities, such as swimming, accidental ingestion of the water may occur and there is direct contact to sensitive body organs, such as the eyes, ears, and nose. Whole body contact category A applies to waters that have been established by the property owner as public swimming areas and waters with documented existing whole body contact recreation uses by the public (10 CSR 20-7.031(1)(C)2.A.(I)). Whole body contact category B applies to waters designated for whole body contact recreation not contained within category A (10 CSR 20-7.031(1)(C)2.A.(II)). Secondary contact recreation, which includes activities such as boating, fishing, and wading, are activities that may result in contact with the water that is either incidental or accidental and the probability of ingesting appreciable quantities of water is minimal (10 CSR 20-7.031(1)(C)2.B.). The secondary contact recreation uses are not impaired in North, Middle, or South Indian Creeks.

3.2 Water Quality Criteria

Water quality criteria represent a level of water quality that supports and protects particular designated uses. Water quality criteria are expressed as specific numeric criteria and as general

[9] https://www.epa.gov/wqs-tech/water-quality-standards-handbook

narrative statements. Missouri's Water Quality Standards (10 CSR 20-7.031(4) and (5)) establish general criteria applicable to all waters of the state at all times and specific criteria applicable to waters contained in 10 CSR 20-7.031, Tables G and H. Specific numeric *E. coli* bacteria criteria are given in Missouri's Water Quality Standards at 10 CSR 20-7.031(5)(C) and Table A1. For whole body contact recreation category B waters, *E. coli* concentrations during the recreational season (April through October) shall not exceed the geometric mean of 206 colony forming units (cfu) per 100 milliliters (mL) of water. This criterion is also protective of secondary contact recreational uses.

3.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation and may be found at 10 CSR 20-7.031(3).

Tier 1 – Protects public health, existing instream water uses, and a level of water quality necessary to maintain and protect existing uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after November 28, 1975, the date of EPA's first water quality standards regulations related to existing uses.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters, such as waters of national and state parks, wildlife refuges, and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

Waters in which a pollutant is at, near, or exceeds the water quality criteria are considered in Tier 1 status for that pollutant. Therefore, the antidegradation goals for North, Middle, and South Indian Creeks are to restore water quality to levels that meet water quality standards.

4. Defining the Problem

E. coli are bacteria found in the intestines of humans and warm-blooded animals and are used as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. In accordance with Missouri's 2020 Listing Methodology Document, the whole body contact recreation category B designated uses for North, Middle, and South Indian Creeks are impaired because the geometric means of *E. coli* samples collected during the recreational season were greater than 206 cfu/100 mL in the most recent three years having available data with five or more samples.[10]

[10] Listing Methodology documents are available online at dnr.mo.gov/env/wpp/waterquality/303d/303d.htm

Sufficient data consistent with the assessment methodology are available to support these listings as summarized in Table 8 and Figure 7. As shown, *E. coli* concentrations exceeded the geometric mean of 206 cfu/100 mL during the recreational season in North and Middle Indian Creeks in 2007, and South Indian Creek in 2007 and 2012.

Individual *E. coli* measurements are provided in Appendix A to illustrate the nature of the impairment but were not used in the calculation of TMDL loading capacities or allocations. Individual measurements may be used to estimate pollutant reduction targets, to target implementation activities, and to select appropriate best management practices. Reduction targets for North, Middle, and South Indian Creeks are presented in a supplemental TMDL implementation strategies document available online at dnr.mo.gov/env/wpp/tmdl/3259-3260-3263-north-middle-south-indian-creek-water-body-record.htm.

Table 8. Summary of Recreational Season *E. coli* Data for the Impaired Water Bodies

Water Body	Recreational Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean (cfu/100 mL)
South Indian Creek WBID 3259	2007	97	1.0	4,839	270
	2012	6	33.6	4,106	382
	2013	13	13.1	738	128
North Indian Creek WBID 3260	2007	24	90.6	1,046	280
Middle Indian Creek WBID 3263	2007	25	98.8	1,046	325

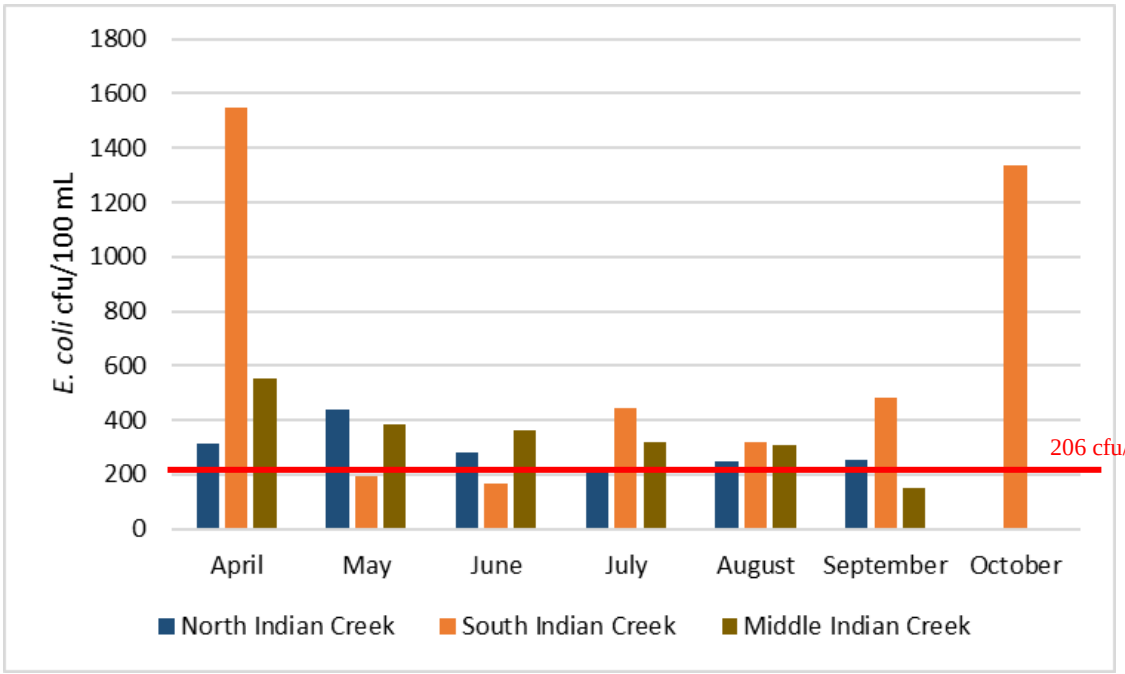

Figure 7. Geometric Means of *E. coli* Data by Month

5. Source Inventory and Assessment

Point (typically regulated) and nonpoint (typically unregulated) sources may contribute to the elevated *E. coli* concentrations in the impaired water bodies. The following source inventory and assessment identifies and characterizes known, suspected, and potential sources of bacteria loading to North, Middle, and South Indian Creeks. Sources of bacteria loading are identified and quantified to the extent that information is available.

5.1 Point Sources

Point sources are defined by Section 644.016(16) of the Missouri Clean Water Law and are regulated pursuant to the National Pollutant Discharge Elimination System through the Missouri State Operating Permit program.[11] A point source is defined as "any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. Point source does nont include agricultural storm water discharges and return flows from irrigated agriculture." Based on this definition, point sources include domestic wastewater treatment facilities, industrial and commercial facilities, concentrated animal feeding operations (CAFOs), MS4s, and stormwater discharges from industrial areas and construction sites. Illicit straight pipe discharges are also point sources but are illegal and therefore unpermitted. Pollutant loading from point sources is typically most evident during low-flow conditions when stormwater influences are lower or nonexistent. The locations of permitted point sources in the North, Middle, and South Indian Creek watersheds are presented in Figure 8.[12]

[11] The Missouri State Operating Permit program is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES). Generally, the Clean Water Act requires all point sources that discharge pollutants to waters of the United States to obtain an NPDES permit. Issued and proposed operating permits are available online at dnr.mo.gov/env/wpp/permits/index.html.

[12] Facilities and their expected contributions to the impaired streams are described individually in the following sections. Due to the large number of CAFOs, Map IDs are provided for those facilities.

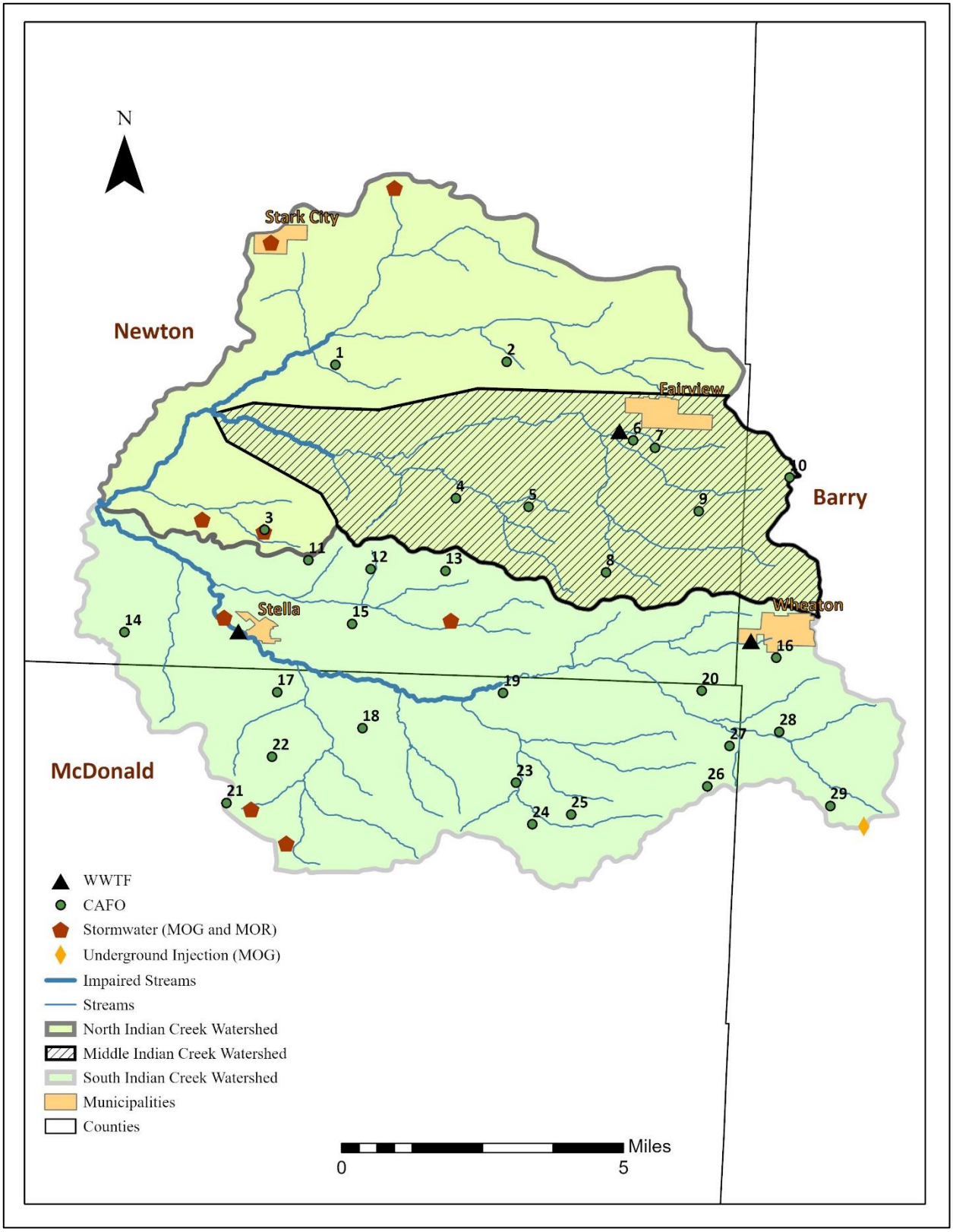

Figure 8. Permitted Features and Outfalls in the North, Middle, and South Indian Creek Watersheds

5.1.1 Domestic Wastewater Treatment Facilities

Domestic wastewater is primarily household waste, including graywater and sewage. Domestic wastewater treatment facilities include both publicly owned (municipal and sewer districts) and privately owned facilities. Untreated or inadequately treated domestic wastewater discharges can be significant sources of bacteria to receiving waters (USEPA 1986). Facilities equipped with disinfection technologies discharge *E. coli* at very low concentrations and should not cause or contribute to bacteria impairments.

The cities of Fairview, Stella, and Wheaton operate municipal domestic wastewater treatment facilities (Table 9). The Fairview facility is located in the Middle Indian Creek watershed and is also within the North Indian Creek watershed. The Stella and Wheaton facilities are located in the South Indian Creek watershed. There are no privately owned domestic wastewater treatment facilities in the North, Middle, or South Indian Creek watersheds. All three facilities land apply wastewater through irrigation systems and do not discharge directly to surface waters. The Fairview land application field is located approximately 4.5 miles upstream from the impaired segment of Middle Indian Creek. The Wheaton land application field is located 3.9 miles upstream of the impaired segment of South Indian Creek. The Stella land application field is located near the impaired segment of South Indian Creek. However, permits for these facilities require setbacks from streams and other conditions to minimize bacteria loading to surface waters. When all permit requirements are met, the three municipal wastewater treatment facilities are not exptected to contribute to the water quality impairments of North, Middle, and South Indian Creeks.

Table 9. Domestic Wastewater Treatment Facilities in the North, Middle, and South Indian Creek Watersheds

Facility	Permit Number	Treatment Type	Permit Expiration[13]
Fairview	MO-0112631	Two-cell lagoon; wastewater is land applied (irrigation)	3/31/2025
Stella	MO-0124281	Two-cell lagoon; wastewater is land applied (irrigation)	3/31/2020
Wheaton	MO-0041041	No discharge storage and irrigation system for year-round flows into lagoon	3/31/2025

Potential bacteria loading from domestic wastewater treatment facilities may also occur from sanitary sewer overflows. Sanitary sewer systems convey residential wastewater, and in some cases commercial and industrial wastewater, to the domestic wastewater treatment facility. Sanitary sewer systems can handle limited amounts of inflow from stormwater and infiltration from groundwater but are typically not designed to collect large amounts of runoff from precipitation events. Overflows from sanitary sewer systems may result in elevated bacteria counts in nearby surface waters (USEPA 1996). Sanitary sewer overflows can be caused by high volume precipitation events and can also occur during dry weather due to blockages, line breaks, sewer defects, power failures, and vandalism. Sanitary sewer overflows can occur at any point in the collection system but are typically evident by overflowing manholes and backups into private residences. Such overflows may discharge directly to nearby waterways or may be restricted to terrestrial locations. These discharges are not authorized by the federal Clean Water Act or the Missouri Clean Water Law.

[13] When an NPDES permit expires, the permittee remains bound by the conditions of that expired permit until either the permit is terminated or a new permit is issued.

The Stella Wastewater Treatment Facility reported one sanitary sewer overflow in 2017. The Fairview and Wheaton facilities have not reported any sanitary sewer overflows in the last five years. Sanitary sewer overflows are not expected to be a significant contributor of *E. coli* to the impaired water bodies because unintentional discharge of untreated domestic wastewater is rare and temporary in nature. NPDES permits and 40 CFR Part 122.41(e) require permittees to properly operate and maintain their collection systems. This is implemented through a special permit condition or schedule of compliance.

5.1.2 Industrial and Commercial Facilities

Industrial and commercial facilities discharge process water used or generated during mining, manufacturing, or food processing activities, and may also include landfills. Mining and manufacturing facilities are not expected to cause or contribute to bacteria impairments. Food processing wastewater may contain bacteria. There are no site-specific permitted industrial or commercial facilities in the North, Middle, or South Indian Creek watersheds. One general permitted food processing facility is located in the South Indian Creek watershed. The 4A's Meat Processing facility (MO-G822218, expiration 5/22/2022) holds a general permit for land application of food processing wastewater. This facility is not authorized to discharge to surface waters. If this facility meets all land application permit requirements, it will not be a significant contributor of *E. coli* to the South Indian Creek watershed. General permits are further discussed in Section 5.1.5.

5.1.3 Concentrated Animal Feeding Operations

Animal wastes generated from CAFOs that are used as fertilizer can be a source of bacteria to water bodies (Rogers and Haines 2005). Pursuant to 10 CSR 20-6.300, permits are required for CAFOs that confine and feed or maintain more than 1,000 animal units for 45 days or more during any 12-month period.[14] Permits may be required for facilities with fewer animal units if pollutants are discharged directly into waters of the state or other water quality issues are discovered. In Missouri, CAFOs are subject to the requirements of site-specific permits or one of two general permits (MO-G01 or MO-GS1).[15]

Twenty-nine Class IC broiler chicken CAFO facilities are present in the North, Middle, and South Indian Creek watersheds.[16] Table 10 lists the CAFO facilities by watershed. All CAFO facilities in these watersheds operate under the MO-GS1 general permit. Under the MO-GS1 permit, CAFO facilities are not allowed to discharge for any reason, without exception, and any discharge is a violation. Animal waste applied on areas under the control of a CAFO are subject to conditions found in the permit, which include a nutrient management plan developed by the facility.

[14] Per 10 CSR 20-6.300(1)(B)2, An animal unit is a unit of measurement to compare various animal types at an animal feeding operation. One (1) animal unit equals the following: 1.0 beef cow or feeder, cow/calf pair, veal calf, or dairy heifer; 0.5 horse; 0.7 mature dairy cow; 2.5 swine weighing over 55 pounds; 10 swine weighing less than 55 pounds; 10 sheep, lamb, or meat and dairy goats; 30 chicken laying hens or broilers with a wet handling system; 82 chicken laying hens without a wet handling system; 55 turkeys in grow-out phase; 125 chicken broilers, chicken pullets, or turkey poults in brood phase without a wet handling system.

[15] Process wastes are collected and reused as fertilizer by spreading onto agricultural fields at agricultural rates. The MO-GS1 does not authorize any direct discharges. The MO-G01 allows discharge only in the event of weather that exceeds the criteria of a catastrophic storm, and only authorizes discharge of the portion of stormwater flow that exceeds the design storm event, which includes the direct precipitation and runoff from the 25-year, 24-hour storm event.

[16] An operation's "class size" is a category that is based upon the total number of animal units confined at an operation. The Class IC, IB, and IA are categories that start at 1,000, 3,000 and 7,000 animal units respectively, and are required by state regulation to obtain a permit. (1,000 animal units is equal to 2,500 swine; 100,000 broilers; 700 dairy cows; or 1,000 beef steers).

Section 640.760 RSMo establishes setback distances for surface application of liquefied manure from a CAFO by a third party.[17] Pursuant to Section 640.760 RSMo, the Department may enforce stricter setbacks. For these reasons, manure application conducted by the CAFO facilities in compliance with permit conditions are not expected to contribute significant bacteria loads to water bodies in the North, Middle, or South Indian Creek watersheds.

Table 10. CAFOs in the North, Middle, and South Indian Creek Watersheds

Watershed	Map ID	Permit No.	Facility Name
North Indian Creek	1	MOGS10316	Trammell Ranch
	2	MOGS10198	Lungstrum Farm
	3	MOGS10540	Hillcrest Broiler Farm
Middle and North Indian Creek	4	MOGS10224	Sunset Acres Poultry
	5	MOGS10543	RLA Farm
	6	MOGS10258	Kruse Farms Inc
	7	MOGS10576	Terry Ledbetter Broiler Operation
	8	MOGS10254	Aikins Poultry
	9	MOGS10398	Banks Farms
	10	MOGS10108	T and T Farm
South Indian Creek	11	MOGS10292	Benjamin Farm
	12	MOGS10414	Milk N Whey
	13	MOGS10512	Shepherds Farm, LLC
	14	MOGS10438	Do-Si-Dos Farm
	15	MOGS10187	Keith Guinn
	16	MOGS10025	Rual Farm
	17	MOGS10261	Lian Family Farm
	18	MOGS10404	Lal Cue Bawi Solomon
	19	MOGS10139	Cheng Pao Vang
	20	MOGS10262	Kao Yang
	21	MOGS10202	Tou Yongma Farm
	22	MOGS10143	Ahmed Farm, LLC
	23	MOGS10399	David Moore
	24	MOGS10266	Van Ceu
	25	MOGS10244	Chris Narron DBA Dominic Farm
	26	MOGS10153	Aung Thang
	27	MOGS10253	Michael Smith
	28	MOGS10458	Ni To
	29	MOGS10235	Rivera's Farms, LLC

[17] Section 640.760 RSMo setback distances are: 50 feet from a property boundary, 300 feet from any public drinking water lake, 300 feet from any public drinking water intake structure, 100 feet from any perennial and intermittent streams without vegetation abutting such streams, and 35 feet from any perennial and intermittent streams with vegetation abutting such streams.

5.1.4 Municipal Separate Storm Sewer Systems

Municipal separate storm sewer systems (MS4s) are stormwater conveyance systems owned by a public entity that are not part of a sanitary sewer system, a combined sewer system, or part of a domestic wastewater treatment facility. Federal regulations issued in 1990 require that discharges from MS4s be regulated by permits if the population of a municipality, or in some cases a county, is 100,000 or more. As of 1999, new federal regulations require permits for discharges from small MS4s that are located within a U.S. Census Bureau defined urban area or are required to hold a MS4 permit based on other criteria by the permitting authority. As discussed in Section 2.3, at the time of the 2010 census, the U.S. Census Bureau did not designate any areas in the watersheds as urban areas. There are no regulated MS4s in the North, Middle, or South Indian Creek watersheds. Unregulated runoff from developed areas is discussed in Section 5.2.2.

5.1.5 Other General Permitted Wastewater and Stormwater Discharges

General permits are issued for certain wastewater (MO-G) and stormwater (MO-R) discharges based on the type of activity and are intended to be flexible enough to allow for ease and speed of issuance, but must also protect water quality. General wastewater and stormwater permits are issued for activities similar enough to be covered by a single set of requirements. Table 11 lists the effective stormwater discharge permits in the North and South Indian Creek watersheds as of June 2020. There are currently no regulated stormwater discharges in the Middle Indian Creek watershed. Permits associated with construction or land disturbance activities (MO-RA) are temporary. The number of permits of this type may vary in any given year. One general wastewater permit for the 4A's Meat Processing facility is located in the South Indian Creek watershed and was discussed previously in Section 5.1.2.

Existing and future activities for which general wastewater or stormwater permits are issued are expected to be conducted in compliance with all permit conditions including monitoring requirements and discharge limitations. Permit conditions are intended to protect the designated uses of all water bodies within the watershed. Activities conducted in accordance with general wastewater and stormwater permit requirements are not expected to contribute *E. coli* loads in amounts substantial enough to cause or contribute to surface water impairments. Per 10 CSR 20-6.010(13)(C), if at any time the Department determines that a general permit is not providing adequate water quality protection, the Department may require the owner or operator of a permitted site or activity to obtain a site-specific operating permit.

Table 11. General Stormwater Permits in the North and South Indian Creek Watersheds

Watershed	Permit No.	Facility Name	Permit Type	Expires
North Indian Creek	MO-RA14592	Sai Kao Yang	Construction or Land Disturbance	2/7/2022
	MO-RA09938	Hillcrest Broiler Farm		
	MO-R240032	Barry County Farmers Cooperative	Agrichemical facilities	4/30/2024
	MO-R240560	Renner Spray Service, Inc.		
South Indian Creek	MO-RA14101	Lo Farm	Construction or Land Disturbance	7/2/2022
	MO-RA13711	Cross Hen Farm		
	MO-RA12984	Vue Farms		
	MO-RA09843	Stella Wastewater Treatment Facility		

5.1.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges of domestic wastewater are also potential sources of bacteria. These types of sewage discharges bypass treatment systems, such as septic tanks or sanitary sewers, and discharge directly to a stream or an adjacent land area (Brown and Pitt 2004). Illicit straight pipe discharges are illegal and are not authorized by the federal Clean Water Act or the Missouri Clean Water Law. At present, there are no data about the presence or number of illicit straight pipe discharges in the North and South Indian Creek watersheds. For this reason, it is unknown to what significance straight pipe discharges contribute bacteria loads to surface waters in the watershed. Due to the illegal nature of these discharges, any identified illicit straight pipe discharges must be eliminated.

5.2 Nonpoint Sources

Nonpoint sources are diffuse sources with no discernible, confined, or discrete conveyance, and include all categories of discharge that do not meet the definition of a point source. Nonpoint sources are not regulated by the federal Clean Water Act and are exempt from Department permit requirements by state regulation 10 CSR 20-6.010(1)(B)1. Nonpoint source pollutants are typically transported by stormwater runoff, which is minor or negligible during dry weather conditions. Nonpoint sources include agricultural lands, onsite wastewater treatment (septic) systems, and developed areas that do not have regulated storm sewer systems. Nonpoint source pollution can also result from natural background contributions, such as wildlife waste. Streams with little to no riparian buffer are most susceptible to nonpoint source pollution.

5.2.1 Agricultural Lands

Croplands, pasturelands, and low-density animal feeding operations are potential sources of bacteria in surface waters. Bacteria are transported in runoff from areas fertilized with animal manure and where livestock are present. Runoff can result from precipitation or excessive irrigation. Soil and Water Conservation Districts provide funding and guidance for the development of nutrient management plans for unregulated private lands. Areas where nutrient management plans guide manure application and where best management practices are used to reduce soil erosion contribute less bacteria to surface waters than unmanaged areas. Although grazing areas are typically well vegetated, livestock tend to congregate near feeding and watering areas, which can create barren areas that are susceptible to erosion (Sutton 1990). Additionally, livestock that are not excluded from streams will deposit manure, and thus bacteria, directly into the waterway.

As noted in Section 2.4 of this document, the North, Middle, and South Indian Creek watersheds are dominated by grassland and pasture. Aside from livestock present in permitted CAFOs, the exact type and number of livestock present in the North, Middle, and South Indian Creek watersheds are unknown. Since there are no cattle CAFOs in the watersheds, the number of cattle in each watershed can be estimated from county cattle population numbers provided in the U.S. Department of Agriculture's 2017 Census of Agriculture (NASS 2017). Based on the 2017 agricultural census there are an average of 121 cows per square mile of grassland or pasture in Newton, McDonald, and Barry counties.[18] This indicates that there are 4,172 cows in the North Indian Creek watershed, 2,063 cows in the Middle Indian Creek watershed, and 4,696 cows in the South Indian Creek watershed. The U.S. Department of Agriculture estimates that a 1,000-pound beef cow produces

[18] This analysis assumes all areas identified as grassland or pasture are being used for cattle grazing and that cattle are evenly distributed among those areas. Additionally, although some animals may be confined in some areas, for purposes of this estimation the entire cattle population was assumed to be grazing on pasture areas.

approximately 59.1 pounds (26.8 kilograms) of manure per day (USDA 1995). Another study found that 1 gram of fresh manure from a cow on pasture contains a population of approximately 758,577 *E. coli* (Weaver et al. 2005). A single *E. coli* cell can grow into a colony containing 10^8 cells every 12 hours (Lodish et al. 2000). This means that each 1,000-pound cow has the potential to produce 422 cfu per day.

Other types of livestock such as horses and sheep may also be contributing bacteria loads in the North, Middle, and South Indian Creek watersheds. The number and distribution of other animals in the watershed cannot be estimated from available data. Strategies to reduce *E. coli* loading from agricultural areas are outlined in the supplemental Implementation Strategies document located at dnr.mo.gov/env/wpp/tmdl/3259-3260-3263-north-middle-south-indian-creek-water-body-record.htm.

5.2.2 Runoff from Developed Areas

As discussed in Section 5.1.4, there are no regulated MS4s in the North, Middle, or South Indian Creek watersheds. Stormwater runoff from municipal areas may carry high levels of bacteria exceeding water quality criteria during and immediately after storm events (USEPA 1983). *E. coli* contaminated runoff can come from heavily paved areas and areas where soil erosion is common. Common sources of *E. coli* contamination in urban stormwater have been documented as originating from birds, dogs, cats, and rodents (Burton and Pitt 2002). Irrigation runoff from residential lawns where pet wastes are present may also contribute *E. coli* loads to surface waters.

As presented in Section 2.4, developed areas cover small portions of the total North, Middle, and South Indian Creek watersheds. Areas categorized as low to high intensity development comprise approximately 1.4 percent of each watershed and areas described as developed open space comprise approximately 4 percent of each watershed. Degradation of water quality associated with imperviousness has been shown to first occur in a watershed at about 10 percent total imperviousness and to increase in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994). Due to the small amount of development in the watersheds, runoff from these areas is not expected to contribute substantial amounts of *E. coli* to the impaired water bodies. If the developed areas are expanded in the future, best management practices and low impact development should be considered to mitigate pollutant loading from impervious surfaces.

5.2.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment (septic) systems treat and disperse domestic wastewater on the property where it is generated. When properly designed and maintained, these systems perform well and should not contribute substantial amounts of *E. coli* to surface waters. However, when these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface water quality (Horsley and Witten 1996). The Missouri Department of Health and Senior Services or local administrative authorities (commonly the local health department) have jurisdiction over onsite wastewater treatment systems with a design or actual flow of 3,000 gallons per day or less. Municipalities or counties may impose more stringent or additional requirements for owners of septic systems. The Missouri Department of Health and Senior Services estimates that approximately 25 percent of homes in Missouri utilize onsite wastewater treatment systems, particularly in rural areas where public sewer systems are not available (DHSS 2018). Failing onsite wastewater treatment systems can contribute *E. coli* to nearby streams under wet or dry weather conditions directly or through surface runoff and groundwater flows.

The exact number of onsite wastewater treatment systems in the North, Middle, and South Indian Creek watersheds is unknown. EPA's online input data server for the Spreadsheet Tool for Estimating Pollutant Load (STEPL) provides estimates of septic system numbers by 12-digit HUC watersheds based on 1992 and 1998 data from the National Environmental Service Center (USEPA 2014b).[19] These STEPL derived estimates of septic system numbers are provided in Table 12. Due to modest increases in the rural population of the watersheds since the 1990 census, this data is assumed to provide a reasonable estimate of actual septic system numbers.

Septic systems fail due to age and poor maintenance. Table 12 also provides statewide estimated failure rates from a study by the Electric Power Research Institute (EPRI 2000). The study suggests that in parts of Missouri, up to 50 percent of onsite wastewater treatment systems may be failing. Due to these high failure rates, onsite wastewater treatment systems are potential sources of bacteria loading to surface waters in Missouri. However, aerial imagery indicates that there are few residences in close proximity to North, Middle, and South Indian Creeks, so *E. coli* loading to the impaired streams from septic systems is likely minimal.

Table 12. STEPL Derived Estimates of Septic System Numbers

12-digit HUC	Watershed Name	No. of Systems	Population per System	Statewide Failure Rates
110702080301	North Indian Creek	455	2	30% – 50%
110702080302	South Indian Creek	466	2	

5.2.4 Natural Background Contributions

Wildlife such as deer, waterfowl, raccoons, rodents, and other animals contribute to the natural background concentrations of *E. coli* that may be found in a water body. Such contributions may be a component of runoff from agricultural areas, developed areas, forest lands, and other areas. While typical wildlife populations are not expected to cause or contribute to water body impairments, animals that congregate in large groups on or near water bodies may contribute significant bacteria to surface waters. For instance, Canada geese have been found to contribute significant bacteria loads in some waters (Ishii et al. 2007). There are no watershed-specific population data for Canada geese or other waterfowl, but the Missouri Department of Conservation estimated that the statewide resident Canada goose population was approximately 55,000 birds in 2016 and that the five-year average statewide duck population is 393,858 birds (MDC 2016; MDC 2020). The exact number of deer in the watershed is also not known, but the Missouri Department of Conservation keeps harvest records by county for each hunting season. Harvest data provides a general idea of the amount of deer that may be present in an area. Average yearly harvests between 2017 and 2020 in Barry, McDonald, and Newton Counties were 380 deer (MDC 2020). Natural background contributions are included in the nonpoint source load allocations.

5.2.5 Riparian Corridor Conditions

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the attenuation of pollutants in runoff. Land cover within 100 feet of streams in the North, Middle, and

[19] The National Environmental Services Center is located at West Virginia University and maintains a clearinghouse for information related to, among other things, onsite wastewater treatment systems. Available URL: www.nesc.wvu.edu/

South Indian Creeks watersheds are presented in Tables 13, 14, and 15. Agricultural areas constitute over 58 percent of the riparian corridors of streams in the North and Middle Indian Creek watersheds and about 70 percent of the riparian corridors in the South Indian Creek watershed. These areas may be more susceptible to *E. coli* loading. Over 30 percent of the riparian corridors in the North and Middle Indian Creeks watersheds are forested and over 20 percent of the riparian corridors in South Indian Creek watershed. This indicates that some *E. coli* transported from adjacent cropland and pasture lands into those areas may be intercepted before it enters the streams.

Table 13. Land Cover in Riparian Corridors in the North Indian Creek Watershed

Land Cover Type	Riparian Corridor Land Cover Type Area	
	Acres	**Percent**
Developed, Low Intensity	0.66	0.05%
Developed, Medium Intensity	0.21	0.02%
Developed, Open Space	48.37	3.56%
Cultivated Crops	23.53	1.73%
Grassland and Pasture	783.97	57.63%
Forest	471.24	34.64%
Shrub and Herbaceous	16.12	1.19%
Wetlands	14.00	1.03%
Open Water	2.18	0.16%
Total:	1,360.29	100.00%

Table 14. Land Cover in Riparian Corridors in the Middle Indian Creek Watershed

Land Cover Type	Riparian Corridor Land Cover Type Area	
	Acres	**Percent**
Developed, Low Intensity	0.36	0.05%
Developed, Medium Intensity	0.01	0.00%
Developed, Open Space	15.51	2.38%
Cultivated Crops	7.94	1.22%
Grassland and Pasture	373.63	57.30%
Forest	236.86	36.33%
Shrub and Herbaceous	8.98	1.38%
Wetlands	6.54	1.00%
Open Water	2.18	0.33%
Total:	652.01	100.00%

Table 15. Land Cover in Riparian Corridors in the South Indian Creek Watershed

Land Cover Type	Riparian Corridor Land Cover Type Area	
	Acres	Percent
Developed, Low Intensity	1.87	0.12%
Developed, Medium Intensity	2.50	0.15%
Developed, Open Space	46.42	2.88%
Cultivated Crops	13.98	0.87%
Grassland and Pasture	1125.94	69.75%
Forest	366.37	22.70%
Shrub and Herbaceous	1.51	0.09%
Wetlands	53.13	3.29%
Open Water	2.45	0.15%
Total:	1614.16	100.00%

6. Calculating Loading Capacity

A TMDL is equal to the loading capacity of a water body for a specific pollutant, which is the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. The loading capacity is derived from the numeric water quality criterion for each pollutant or an appropriate surrogate when no numeric criterion is applicable. Once the maximum allowable pollutant load is determined, a portion is assigned to point sources as a wasteload allocation and to nonpoint sources as a load allocation. A margin of safety is required to account for uncertainties in scientific and technical understanding of water quality in natural systems (CWA Section 303(d)(l)(C) and 40 CFR 130.7(c)(l)). The loading capacity is equal to the sum of the wasteload allocation, load allocation, and the margin of safety as follows:

$$TMDL = LC = \sum WLA + \sum LA + MOS$$

where LC is the loading capacity, ∑WLA is the sum of the wasteload allocations, ∑LA is the sum of the load allocations, and MOS is the margin of safety.

7. Total Maximum Daily Loads

According to 40 CFR 130.2(i), TMDLs can be expressed in terms of mass per unit time, toxicity, or other appropriate measures. The TMDLs for North, Middle, and South Indian Creeks are expressed as *E. coli* cfu per day using load duration curves developed using the *E. coli* criterion concentration of 206 cfu/100 mL, all possible stream flows, and a unit conversion factor.[20] Establishing TMDLs using load duration curves is consistent with the Anacostia Ruling (*Friends of the Earth, Inc., et al v. EPA*, No 05-5010, April 25, 2006) and EPA guidance in response to that ruling (USEPA 2006; USEPA 2007a).

[20] $\boldsymbol{Load}\left(\frac{\text{count}}{\text{time}}\right) = \boldsymbol{Concentration}\left(\frac{\text{count}}{\text{volume}}\right) * \boldsymbol{Flow}\left(\frac{\text{volume}}{\text{time}}\right) * \boldsymbol{conversion\ factor}$ (24,465,715)

The selected TMDL target is protective of whole body and secondary contact recreational uses. The resulting load duration curves provide a visual representation of the pollutant loading capacity of the water bodies at all stream flows. The TMDLs are applicable during the recreational season when the *E. coli* criterion applies. Using this approach the available loading capacity of the stream varies with flow, but the pollutant concentration remains constant. Although TMDLs are expressed as daily mass loads, *E. coli* criteria are expressed as geometric mean concentrations. Therefore, fluctuations in instantaneous concentrations are expected and individual bacteria measurements greater than the applicable criterion do not necessarily indicate a violation of water quality standards. Additional discussion about the methods used to develop the load duration curves for North, Middle, and South Indian Creeks is provided in Appendix B.

Observed data are plotted on the load duration curve graphs to demonstrate the magnitude of load reductions that are needed to meet the TMDLs and attain water quality standards. Points above the curve exceed the loading capacity and points on or below the curve are in compliance with water quality standards. The load duration curves also help to identify and differentiate between storm-driven loading and the presence of continuous loading. Storm-driven loading is expected under wet conditions when precipitation and runoff are high. Continuous loading is evident at low flows when point source discharges have greater influence on water quality. Load reductions needed to meet the *E. coli* criterion can be calculated using the geometric means of observed data within each flow percentile range and are provided in the supplemental Implementation Strategies document located at dnr.mo.gov/env/wpp/tmdl/3259-3260-3263-north-middle-south-indian-creek-water-body-record.htm.

The *E. coli* load duration curves for North, Middle, and South Indian Creeks are displayed in Figures 9, 10, and 11. The y-axes quantify the *E. coli* mass load in cfu per day at the flow conditions (percentage of time flow is equaled or exceeded) on the x-axes. Lower flows are equaled or exceeded more frequently than higher flows (i.e., greater than 90 percent of the time). The flow ranges are consistent with EPA guidance for using load duration curves to develop TMDLs (USEPA 2007b).

The TMDLs and associated allocations at selected percentile flow exceedances are displayed in Tables 16, 17, and 18. Due to the extremely large numbers associated with bacteria loads, *E. coli* values are presented using scientific notation. Specific allocations for individual sources are discussed in Sections 8 and 9.

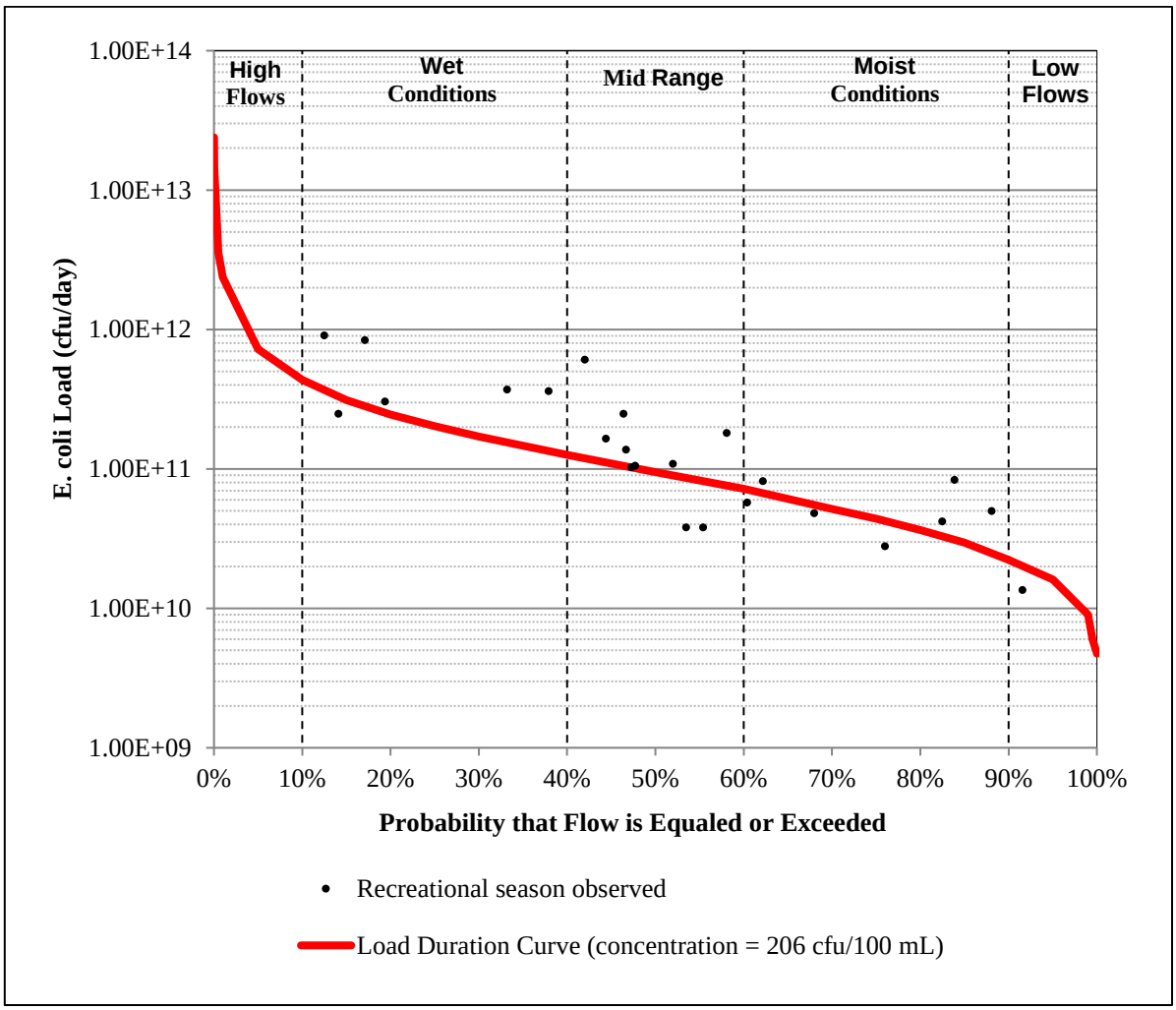

Figure 9. *E. coli* TMDL for North Indian Creek (WBID 3260)

Table 16. *E. coli* TMDL and Allocations for North Indian Creek at Selected Flows

Percent of time flow is equaled or exceeded	Flow ft^3/s	LC (counts/day)	∑WLA (counts/day)	∑LA (counts/day)	MOS (counts/day)
95	3.20	1.61E+10	0	1.45E+10	1.61E+09
75	8.74	4.41E+10	0	3.97E+10	4.41E+09
50	18.86	9.51E+10	0	8.56E+10	9.51E+09
25	40.29	2.03E+11	0	1.83E+11	2.03E+10
5	143.85	7.25E+11	0	6.53E+11	7.25E+10

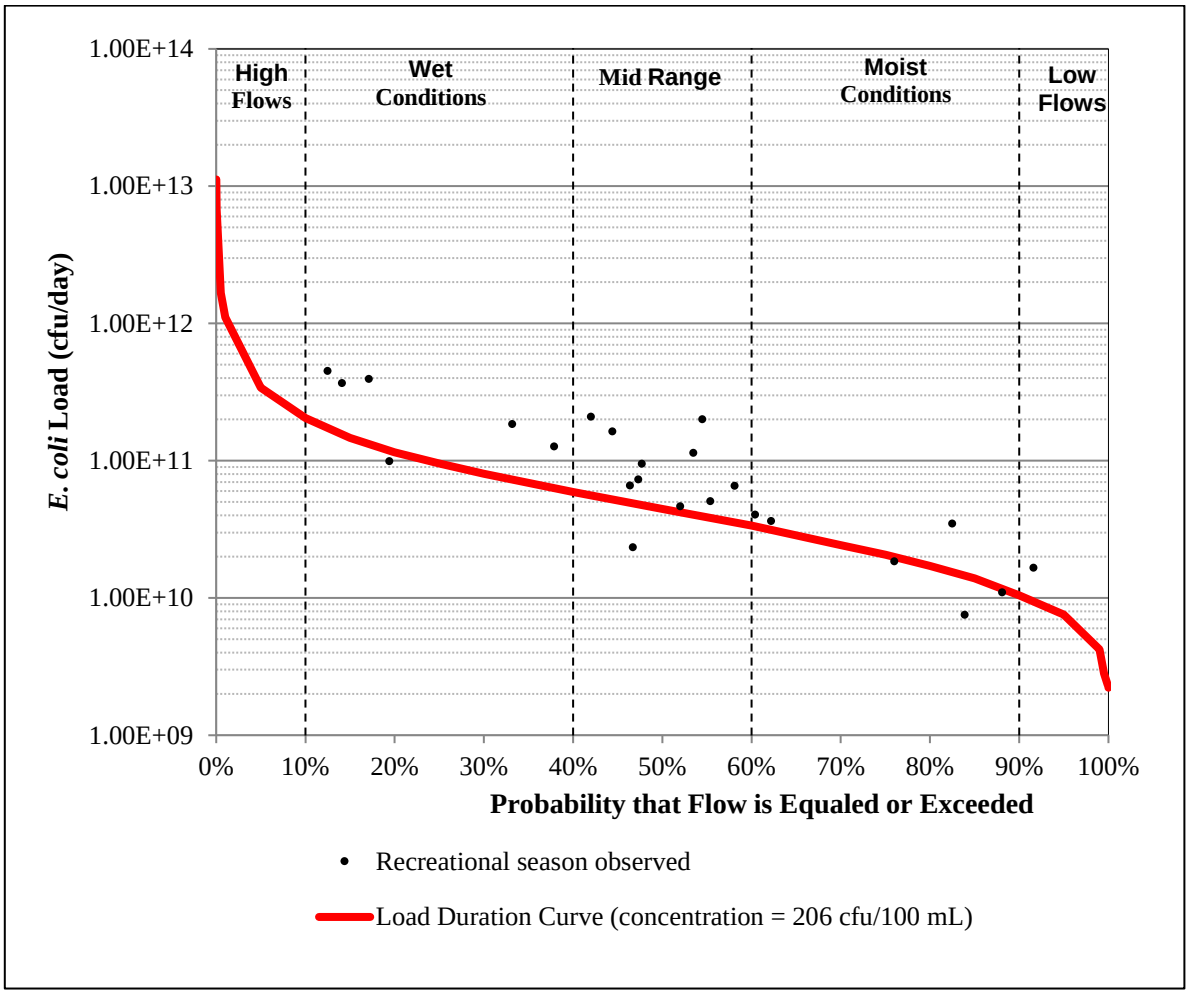

Figure 10. *E. coli* TMDL for Middle Indian Creek (WBID 3263)

Table 17. *E. coli* TMDL and Allocations for Middle Indian Creek at Selected Flows

Percent of time flow is equaled or exceeded	Flow ft^3/s	LC (counts/day)	∑WLA (counts/day)	∑LA (counts/day)	MOS (counts/day)
95	1.50	7.56E+09	0	6.80E+09	7.56E+08
75	4.10	2.07E+10	0	1.86E+10	2.07E+09
50	8.84	4.46E+10	0	4.01E+10	4.46E+09
25	18.89	9.52E+10	0	8.57E+10	9.52E+09
5	67.43	3.40E+11	0	3.06E+11	3.40E+10

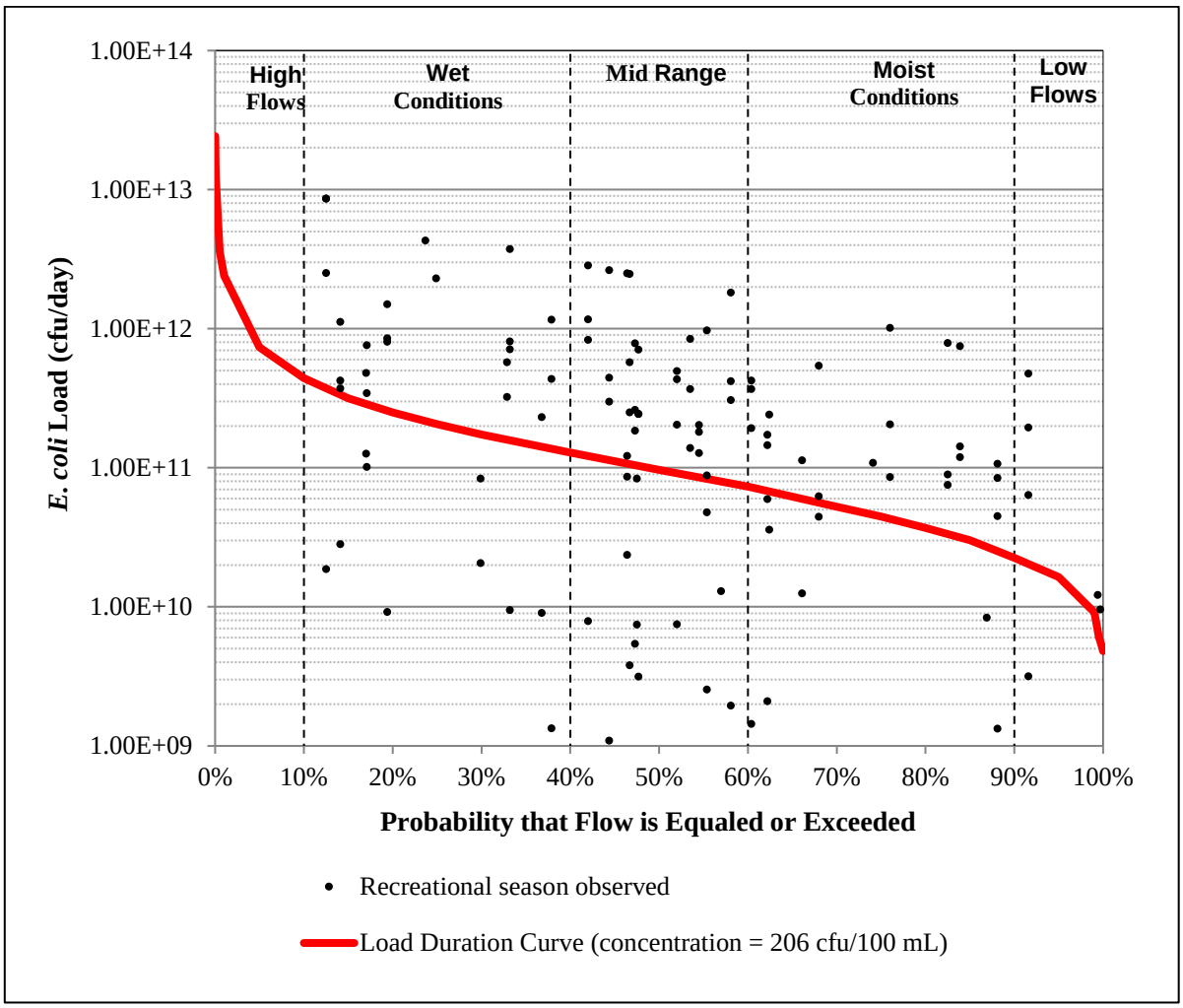

Figure 11. *E. coli* TMDL for South Indian Creek (WBID 3259)

Table 18. TMDL and Allocations for South Indian Creek at Selected Flows

Percent of time flow equaled or exceeded	Flow ft^3/s	TMDL (counts/day)	∑WLA (counts/day)	∑LA (counts/day)	MOS (counts/day)
95	3.25	1.64E+10	0	1.47E+10	1.64E+09
75	8.87	4.47E+10	0	4.02E+10	4.47E+09
50	19.14	9.64E+10	0	8.68E+10	9.64E+09
25	40.88	2.06E+11	0	1.85E+11	2.06E+10
5	145.95	7.36E+11	0	6.62E+11	7.36E+10

8. Wasteload Allocation (Point Source Load)

The wasteload allocation is the portion of the loading capacity assigned to existing or future point sources. No portion of the *E. coli* loading capacities for North, Middle, and South Indian Creeks were allocated to point sources because the existing point sources either do not discharge wastewater that contains *E. coli* or operate under permits that do not allow discharge to surface waters. Pursuant to 40 CFR 122.44(d)(1)(vii)(B), effluent limits or other permit conditions must be consistent with the assumptions and requirements of TMDL wasteload allocations.

The wasteload allocations presented in this TMDL report do not preclude the establishment of future point sources. Any future point sources should be evaluated against the TMDL, the range of flows with which any additional bacterial loading will affect, and any additional requirements associated with antidegradation. Federal regulation 40 CFR 122.4(a) disallows the issuance of an NPDES permit if the conditions of the permit cannot provide for compliance with the applicable requirements of the federal Clean Water Act, or regulations promulgated under the federal Clean Water Act. Additionally, 40 CFR 122.4(i) states no permit may be issued to a new source or new discharger if the discharge from its construction or operation will cause or contribute to violation of water quality standards. After undergoing antidegradation review, any new facility that discharges wastewater containing *E. coli* will be required to disinfect its effluent during the recreational season or use other approaches (e.g., no discharge or batch discharges) that will result in *de minimis* bacteria loading during the recreational season and will therefore not cause or contribute to the impairment. Decommissioning of onsite wastewater treatment systems and connecting to a sewerage system for wastewater treatment will result in net pollutant reductions that are consistent with the goals of this TMDL.

8.1 Domestic Wastewater Treatment Facilities

The Fairview municipal wastewater treatment facility is located in the Middle Indian Creek watershed within the North Indian Creek watershed. The Stella and Wheaton municipal wastewater treatment facilities are located in the South Indian Creek watershed. None of these facilities currently discharge directly to surface waters. All three facilities land apply wastewater through irrigation systems. When all permit conditions are met, including those associated with land application, the Fairview, Stella, and Wheaton facilities are not expected to contribute *E. coli* loads above *de minimis* concentrations to surface waters. For these reasons, the *E. coli* wasteload allocations for all domestic wastewater facilities are zero at all flows.

8.2 Industrial and Commercial Facilities

There are currently no site-specific permitted industrial or commercial facilities in the North. Middle, or South Indian Creek watersheds. The 4A's Meat Processing facility holds a general permit that does not allow any discharge to surface waters. When all permit limits and conditions are met, this facility is not expected to cause or contribute to the *E. coli* impairment of South Indian Creek. For this reason wasteload allocations for the 4A's Meat Processing facility is set at existing permit limits and conditions. Wasteload allocations for general permitted facilities are further discussed in Section 8.5.

8.3 Concentrated Animal Feeding Operations

All CAFO facilities in the North, Middle, and South Indian Creek watersheds operate subject to permits that do not allow discharge to surface waters. For this reason, the *E. coli* wasteload allocations for all CAFO facilities are zero at all flows. When all permit conditions are met,

including those associated with land application, CAFO facilities are not expected to contribute *E. coli* loads above *de minimis* concentrations to surface waters. For consistency with TMDL wasteload allocations, new CAFO facilities will be bound to the same permit conditions as the existing facilities.

8.4 Municipal Separate Storm Sewer Systems

There are no regulated MS4s in the North, Middle, or South Indian Creek watersheds. *E. coli* in stormwater runoff from developed areas are included in the load allocation for nonpoint sources. If MS4 permits are required for stormwater discharges from urban areas in the future, then the appropriate proportion of the load allocation, as it relates to stormwater pollutant contributions, may be re-assigned as a wasteload allocation.

8.5 Other General Permitted Wastewater and Stormwater Discharges

Activities that require general or stormwater permits are not typically expected to contribute *E. coli* to surface waters, and permit conditions are protective of the designated uses assigned to all water bodies in the watersheds. Activities for which these permits are issued are expected to be conducted in compliance with all permit conditions, including any land application, monitoring, stormwater pollution prevention plans, and discharge limitations. For these reasons, the *E. coli* wasteload allocations for these facilities are set at existing permit limits and conditions. Future general and stormwater permitted activities that do not actively generate bacteria and that operate in full compliance with permit conditions are not expected to contribute bacteria loads above *de minimis* levels and will not result in loading that exceeds the sum of the TMDL wasteload allocations.

8.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges are illegal and are not permitted under the federal Clean Water Act. For this reason, illicit straight pipe discharges are assigned *E. coli* wasteload allocations of zero. Any existing illicit straight pipe discharges must be eliminated and future discharges of this type should be prevented.

9. Load Allocation (Nonpoint Source Load)

The load allocation is the portion of the loading capacity assigned to existing and future nonpoint sources and natural background contributions (40 CFR 130.2(g)). Because the wasteload allocations for all point sources are zero, the *E. coli* load allocations are equal to the loading capacity minus the margin of safety as presented in Section 7. The load allocations include contributions from agricultural lands, runoff from developed areas, and natural background contributions. No portion of the load allocations is assigned to onsite wastewater treatment systems because when they are properly maintained and operating as designed they do not discharge *E. coli* directly to surface waters.

10. Margin of Safety

A margin of safety is required to account for uncertainties in scientific and technical understanding of water quality in natural systems (CWA Section 303(d)(l)(C) and 40 CFR 130.7(c)(l)). Based on EPA guidance, the margin of safety can be achieved through two approaches:

- Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
- Implicit - Incorporate the margin of safety within the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

An explicit margin of safety equal to 10 percent of the loading capacity is included in the TMDLs. Additionally, bacteria decay rates were not applied and the direct recreational-season geometric mean was used for estimating the daily loading value as required by the federal Clean Water Act. These conservative assumptions serve as an additional implicit margin of safety.

11. Seasonal Variation

Federal regulations at 40 CFR 130.7(c)(1) require that TMDLs take into consideration seasonal variation in applicable water quality standards. The load duration curves provide the *E. coli* loading capacities for each water body at all possible flow regimes using data collected during all seasons. The *E. coli* TMDLs are therefore protective of designated uses throughout the recreational season, including during high flows associated with intense rainfall events when bacteria loading is more likely (the critical condition).

12. Monitoring Plans

The Department conducts water quality monitoring in impaired waters within a reasonable timeframe following the approval of TMDLs, completion of facility upgrades and permit compliance schedules, or the implementation of watershed BMPs. The Department will also routinely examine any available quality-assured water quality data collected by other local, state, and federal entities in order to assess the effectiveness of TMDL implementation. In addition, certain quality-assured data collected by universities, municipalities, private companies, and volunteer groups may be used to assess water quality following TMDL implementation.

13. Reasonable Assurance

Section 303(d)(1)(C) of the federal Clean Water Act requires that TMDLs be established at a level necessary to implement applicable water quality standards. As part of the TMDL process, consideration must be given to the assurances that point and nonpoint source allocations will be achieved and water quality standards attained. Where TMDLs are developed for waters impaired by point sources only, reasonable assurance is provided through the National Pollutant Discharge Elimination System (NPDES) permitting program. State operating permits requiring effluent and instream monitoring be reported to the Department provide reasonable assurance that instream water quality standards will be met.

Where a TMDL is developed for waters impaired by both point and nonpoint sources, point source wasteload allocations must be stringent enough so that in conjunction with the water body's other loadings (i.e., nonpoint sources) water quality standards are met. Reasonable assurance that nonpoint sources will meet their allocated amount is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls, or best management practices within the watershed. If best management practices or other nonpoint source pollution controls allow for more stringent load allocations, then wasteload allocations can be less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs (40 CFR 130.2(i)). When a demonstration of nonpoint source reasonable assurance is developed for an impaired water body, additional pollutant allocations for point sources may be allowed provided water quality standards are still attained. If a demonstration of nonpoint source reasonable assurance does not exist, or it is determined that nonpoint source pollutant reduction plans, controls, or best management practices are not feasible, durable, or will not result in the required load reductions, then allocation of greater pollutant loading to point sources cannot occur.

A variety of grants and loans may be available to assist watershed stakeholders with developing and implementing watershed based plans, controls, and practices to meet the required wasteload and load allocations in the TMDL and demonstrate reasonable assurance. Information regarding potential funding sources, cost-share opportunities, and implementation actions that address nonpoint source loading in the North, Middle, and South Indian Creek watersheds are provided in the supplemental TMDL Implementation Strategies document available online at dnr.mo.gov/env/wpp/tmdl/3259-3260-3263-north-middle-south-indian-creek-water-body-record.htm.

14. Public Participation

EPA regulations at 40 CFR 130.7 require that TMDLs be subject to public review. A 45-day public notice period for this TMDL report was scheduled from October 16, 2020 through November 30, 2020. Groups that directly received notice of the public comment period for this TMDL include, but are not limited to:

- Missouri Clean Water Commission;
- Missouri Department of Conservation;
- Southwest Missouri Council of Governments;
- Newton, Barry, and McDonald County Soil and Water Conservation Districts;
- County health departments;
- County commissions;
- University of Missouri Extension;
- Missouri Coalition for the Environment;
- Stream Teams United;
- Stream Team volunteers living in or near the watershed; and
- Missouri state legislators representing areas within the watershed.

In addition to those groups directly contacted about the public notice, this TMDL report and an implementation strategies document are posted on the Department's TMDL webpage dnr.mo.gov/env/wpp/tmdl/3259-3260-3263-north-middle-south-indian-creek-water-body-record.htm. All comments received during this period and the Department's responses to those comments are also available at this location.

The Department maintains an email distribution list for notifying subscribers of significant TMDL updates or activities, including public notices and comment periods. Those interested in subscribing to TMDL updates can submit their email address using the online form available at public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

15. Administrative Record and Supporting Documentation

The Department has an administrative record on file for the North, Middle, and South Indian Creeks *E. coli* TMDL. The record contains any plans, studies, data, and calculations on which the TMDL is based. It additionally includes the TMDL implementation strategies document, the public notice announcement, any public comments received, and the Department's responses to those comments. This information is available upon request to the Department at dnr.mo.gov/sunshinerequests.htm. The Department will process any request for information about this TMDL in accordance with

Missouri's Sunshine Law (Chapter 610, RSMo) and the Department's administrative policies and procedures governing Sunshine Law requests.

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Appendix A

North, Middle, and South Indian Creeks (WBIDs 3260, 3263, 3259) *E. coli* data collected by the Newton County Health Department (NCHD)

Water Body	Site Description	Sample ID	Site Code	Date	E. coli count/100mL
3260	N. Indian Cr. Just Above M. Indian Cr.	3673	3260/3.0	4/3/2007	307.6
		3674		4/11/2007	90.6
		3675		4/17/2007	613.1
		3676		4/24/2007	547.5
		3677		5/1/2007	488.4
		3678		5/9/2007	517.2
		3679		5/15/2007	248.1
		3680		5/22/2007	1046.2
		3681		5/29/2007	248.9
		3682		6/6/2007	206.4
		3683		6/20/2007	214.2
		3684		6/27/2007	488.4
		3685		7/5/2007	488.4
		3686		7/17/2007	248.9
		3687		7/24/2007	135.4
		3688		7/31/2007	165.8
		3689		8/7/2007	261.3
		3690		8/14/2007	140.1
		3691		8/21/2007	410.6
		3692		8/28/2007	96
		3693		9/4/2007	547.5
		3694		9/12/2007	155.3
		3695		9/18/2007	272.3
		3696		9/25/2007	178.9
3263	M. Indian Cr. Near Mouth	3698	3263/0.3	4/3/2007	648.8
		3699		4/11/2007	579.4
		3700		4/17/2007	613.1
		3701		4/24/2007	410.6
		3702		5/1/2007	517.2
		3703		5/9/2007	547.5
		3704		5/15/2007	172.5
		3705		5/22/2007	770.1
		3706		5/29/2007	228.2
		3707		6/6/2007	313
		3708		6/20/2007	410.6
		3709		6/27/2007	378.4
		3710		7/5/2007	275.5
		3711		7/10/2007	1046.2
		3712		7/17/2007	235.9
		3713		7/24/2007	191.8
		3714		7/31/2007	248.9
		3715		8/7/2007	461.1
		3716		8/14/2007	365.4

Water Body	Site Description	Sample ID	Site Code	Date	E. coli count/100mL
		3717		8/21/2007	193.5
		3718		8/28/2007	272.3
		3719		9/4/2007	105.4
		3720		9/12/2007	488.4
		3721		9/18/2007	98.8
		3722		9/25/2007	108.1
3259	Trib to S. Indian Cr. @ Hwy O	3573	3259/2.6/0.3	4/3/2007	2
	S. Indian Cr. @ Hwy A	3597	3259/3.3	4/3/2007	547.5
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3621	3259/3.7/0.5	4/3/2007	4839.2
	S. Indian Cr. @ Stella	3645	3259/4.0	4/3/2007	816.4
	Trib to S. Indian Cr. @ Hwy O	3574	3259/2.6/0.3	4/11/2007	1
	S. Indian Cr. @ Hwy A	3598	3259/3.3	4/11/2007	325.5
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3622	3259/3.7/0.5	4/11/2007	1986.3
	S. Indian Cr. @ Stella	3646	3259/4.0	4/11/2007	866.4
	Trib to S. Indian Cr. @ Hwy O	3575	3259/2.6/0.3	4/17/2007	73
	S. Indian Cr. @ Hwy A	3599	3259/3.3	4/17/2007	547.5
	S. Indian Cr. @ Stella	3647	3259/4.0	4/17/2007	248.1
	Trib to S. Indian Cr. @ Hwy O	3576	3259/2.6/0.3	4/24/2007	2
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3623	3259/3.7/0.5	4/24/2007	1732.9
	S. Indian Cr. @ Stella	3648	3259/4.0	4/24/2007	648.8
	Trib to S. Indian Cr. @ Hwy O	3577	3259/2.6/0.3	5/1/2007	12.3
	S. Indian Cr. @ Hwy A	3600	3259/3.3	5/1/2007	920.8
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3624	3259/3.7/0.5	5/1/2007	4839.2
	S. Indian Cr. @ Stella	3649	3259/4.0	5/1/2007	1046.2
	Trib to S. Indian Cr. @ Hwy O	3578	3259/2.6/0.3	5/9/2007	10.5
	S. Indian Cr. @ Hwy A	3601	3259/3.3	5/9/2007	1413.6
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3625	3259/3.7/0.5	5/9/2007	4839.2
	S. Indian Cr. @ Stella	3650	3259/4.0	5/9/2007	4839.2
	Trib to S. Indian Cr. @ Hwy O	3579	3259/2.6/0.3	5/15/2007	7.4
	S. Indian Cr. @ Hwy A	3602	3259/3.3	5/15/2007	686.7
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3626	3259/3.7/0.5	5/15/2007	1203.3
	S. Indian Cr. @ Stella	3651	3259/4.0	5/15/2007	648.8
	Trib to S. Indian Cr. @ Hwy O	3580	3259/2.6/0.3	5/22/2007	13.4
	S. Indian Cr. @ Hwy A	3603	3259/3.3	5/22/2007	1986.3

Water Body	Site Description	Sample ID	Site Code	Date	E. coli count/100mL
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3627	3259/3.7/0.5	5/22/2007	4839.2
	S. Indian Cr. @ Stella	3652	3259/4.0	5/22/2007	1413.6
	Trib to S. Indian Cr. @ Hwy O	3581	3259/2.6/0.3	5/29/2007	16.9
	S. Indian Cr. @ Hwy A	3604	3259/3.3	5/29/2007	461.1
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3628	3259/3.7/0.5	5/29/2007	1119.9
	S. Indian Cr. @ Stella	3653	3259/4.0	5/29/2007	980.4
	Trib to S. Indian Cr. @ Hwy O	3582	3259/2.6/0.3	6/6/2007	10.7
	S. Indian Cr. @ Hwy A	3605	3259/3.3	6/6/2007	365.4
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3629	3259/3.7/0.5	6/6/2007	1553.1
	S. Indian Cr. @ Stella	3654	3259/4.0	6/6/2007	517.2
	Trib to S. Indian Cr. @ Hwy O	3583	3259/2.6/0.3	6/20/2007	6.3
	S. Indian Cr. @ Hwy A	3606	3259/3.3	6/20/2007	488.4
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3630	3259/3.7/0.5	6/20/2007	1413.6
	S. Indian Cr. @ Stella	3655	3259/4.0	6/20/2007	488.4
	Trib to S. Indian Cr. @ Hwy O	3584	3259/2.6/0.3	6/27/2007	5.2
	S. Indian Cr. @ Hwy A	3607	3259/3.3	6/27/2007	816
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3631	3259/3.7/0.5	6/27/2007	4839.2
	S. Indian Cr. @ Stella	3656	3259/4.0	6/27/2007	1119.9
	Trib to S. Indian Cr. @ Hwy O	3585	3259/2.6/0.3	7/5/2007	45.7
	S. Indian Cr. @ Hwy A	3608	3259/3.3	7/5/2007	235.9
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3632	3259/3.7/0.5	7/5/2007	4839.2
	S. Indian Cr. @ Stella	3657	3259/4.0	7/5/2007	167
	S. Indian Cr. @ Hwy A	3609	3259/3.3	7/10/2007	488.4
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3633	3259/3.7/0.5	7/10/2007	435.2
	S. Indian Cr. @ Stella	3658	3259/4.0	7/10/2007	307.6
	Trib to S. Indian Cr. @ Hwy O	3586	3259/2.6/0.3	7/17/2007	6.3
	S. Indian Cr. @ Hwy A	3610	3259/3.3	7/17/2007	178.5
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3634	3259/3.7/0.5	7/17/2007	517.2
	S. Indian Cr. @ Stella	3659	3259/4.0	7/17/2007	435.2
	Trib to S. Indian Cr. @ Hwy O	3587	3259/2.6/0.3	7/24/2007	2
	S. Indian Cr. @ Hwy A	3611	3259/3.3	7/24/2007	410.6
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3635	3259/3.7/0.5	7/24/2007	4839.2

Water Body	Site Description	Sample ID	Site Code	Date	E. coli count/100mL
	S. Indian Cr. @ Stella	3660	3259/4.0	7/24/2007	980.4
	Trib to S. Indian Cr. @ Hwy O	3588	3259/2.6/0.3	7/31/2007	4.1
	S. Indian Cr. @ Hwy A	3612	3259/3.3	7/31/2007	547.5
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3636	3259/3.7/0.5	7/31/2007	1203.3
	S. Indian Cr. @ Stella	3661	3259/4.0	7/31/2007	1046.2
	Trib to S. Indian Cr. @ Hwy O	3589	3259/2.6/0.3	8/7/2007	3.1
	S. Indian Cr. @ Hwy A	3613	3259/3.3	8/7/2007	461.1
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3637	3259/3.7/0.5	8/7/2007	4839.2
	S. Indian Cr. @ Stella	3662	3259/4.0	8/7/2007	547.5
	Trib to S. Indian Cr. @ Hwy O	3590	3259/2.6/0.3	8/14/2007	32.3
	S. Indian Cr. @ Hwy A	3614	3259/3.3	8/14/2007	648.8
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3638	3259/3.7/0.5	8/14/2007	4839.2
	S. Indian Cr. @ Stella	3663	3259/4.0	8/14/2007	1986.3
	Trib to S. Indian Cr. @ Hwy O	3591	3259/2.6/0.3	8/21/2007	10.8
	S. Indian Cr. @ Hwy A	3615	3259/3.3	8/21/2007	686.7
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3639	3259/3.7/0.5	8/21/2007	866.4
	S. Indian Cr. @ Stella	3664	3259/4.0	8/21/2007	365.4
	Trib to S. Indian Cr. @ Hwy O	3592	3259/2.6/0.3	8/28/2007	6.3
	S. Indian Cr. @ Hwy A	3616	3259/3.3	8/28/2007	218.5
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3640	3259/3.7/0.5	8/28/2007	2419.6
	S. Indian Cr. @ Stella	3665	3259/4.0	8/28/2007	118.7
	Trib to S. Indian Cr. @ Hwy O	3593	3259/2.6/0.3	9/4/2007	6.1
	S. Indian Cr. @ Hwy A	3617	3259/3.3	9/4/2007	770.1
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3641	3259/3.7/0.5	9/4/2007	4839.2
	S. Indian Cr. @ Stella	3666	3259/4.0	9/4/2007	920.8
	Trib to S. Indian Cr. @ Hwy O	3594	3259/2.6/0.3	9/12/2007	17.3
	S. Indian Cr. @ Hwy A	3618	3259/3.3	9/12/2007	228.2
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3642	3259/3.7/0.5	9/12/2007	686.7
	S. Indian Cr. @ Stella	3667	3259/4.0	9/12/2007	260.3
	Trib to S. Indian Cr. @ Hwy O	3595	3259/2.6/0.3	9/18/2007	7.4
	S. Indian Cr. @ Hwy A	3619	3259/3.3	9/18/2007	1119.9
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3643	3259/3.7/0.5	9/18/2007	4839.2

Water Body	Site Description	Sample ID	Site Code	Date	E. coli count/100mL
	S. Indian Cr. @ Stella	3668	3259/4.0	9/18/2007	488.4
	Trib to S. Indian Cr. @ Hwy O	3596	3259/2.6/0.3	9/25/2007	3.1
	S. Indian Cr. @ Hwy A	3620	3259/3.3	9/25/2007	163.1
	Trib to S. Indian Cr. @ Hwy D and S. Ozark St.	3644	3259/3.7/0.5	9/25/2007	1983.3
	S. Indian Cr. @ Stella	3669	3259/4.0	9/25/2007	228.2
	Macedonia aka HortonSpring pool	229847	3259/2.0/0.8	4/17/2012	4106
	Macedonia aka HortonSpring pool	229848	3259/2.0/0.8	5/15/2012	33.6
	Macedonia aka HortonSpring pool	229849	3259/2.0/0.8	6/26/2012	62
	Macedonia aka HortonSpring pool	229850	3259/2.0/0.8	7/24/2012	348
	Macedonia aka HortonSpring pool	229851	3259/2.0/0.8	8/28/2012	356.5
	Macedonia aka HortonSpring pool	229852	3259/2.0/0.8	9/18/2012	488
	Macedonia aka HortonSpring pool	229853	3259/2.0/0.8	10/15/2012	2282
	Macedonia aka HortonSpring pool	246190	3259/2.0/0.8	4/16/2013	90.8
	S. Indian Cr. @ Stella	246197	3259/4.0	4/16/2013	344.8
	Macedonia aka HortonSpring pool	246191	3259/2.0/0.8	5/28/2013	24.3
	S. Indian Cr. @ Stella	246198	3259/4.0	5/28/2013	98.5
	Macedonia aka HortonSpring pool	246192	3259/2.0/0.8	6/24/2013	14.8
	S. Indian Cr. @ Stella	246199	3259/4.0	6/24/2013	165.8
	Macedonia aka HortonSpring pool	246193	3259/2.0/0.8	7/25/2013	738
	S. Indian Cr. @ Stella	246200	3259/4.0	7/25/2013	414
	Macedonia aka HortonSpring pool	246194	3259/2.0/0.8	8/26/2013	13.1
	S. Indian Cr. @ Stella	246201	3259/4.0	8/26/2013	335.2
	Macedonia aka HortonSpring pool	246195	3259/2.0/0.8	9/23/2013	728.4
	S. Indian Cr. @ Stella	246202	3259/4.0	9/23/2013	108.1
	Macedonia aka HortonSpring pool	246196	3259/2.0/0.8	10/22/2013	42.8
	S. Indian Cr. @ Stella	246203	3259/4.0	10/22/2013	387.3

Appendix B

Development of *E. coli* Load Duration Curves

Overview

Load duration curves were used to develop the *E. coli* TMDLs for North, Middle, and South Indian Creeks. Load duration curves visually display the loading capacity of a water body at all possible flows based on historic flow data and the defined target concentration for each pollutant. For this TMDL no portion of the loading capacity is assigned to a wasteload allocation. Ten percent of the loading capacity is reserved as an explicit margin of safety. The remaining portion of the loading capacity is allocated to nonpoint sources.

Methodology

Load duration curves are based on a flow duration curve developed using a long-term time series of daily average flows and a numeric water quality target. The numeric target for the *E. coli* load duration curves is the whole body contact category B criterion of 206 cfu/100 mL. Because there are no USGS stream gages on North, Middle, or South Indian Creeks, the load duration curves are based on a flow duration curve derived by synthesizing over 18 years of daily average flow data recorded at three USGS stream gages in the Neosho ecological drainage unit, as shown in Table B-1. Nash-Sutcliffe statistics are calculated for each gage flow record in order to determine if the relationship is valid for each record. The Nash-Sutcliffe statistic evaluates the efficiency of a predicted (modeled) flow dataset (Nash and Sutcliffe 1970). An efficiency of 1 (100 percent) describes a perfect match, while values less than zero indicate a poor fit of modeled and observed datasets (USGS 2010). This relationship must be valid in order to use the synthesized flow methodology. Model estimates are considered satisfactory if Nash-Sutcliffe statistics are greater than 50 percent (USGS 2013). The flow duration curves for each reference stream and the resulting synthesized flow are depicted in Figure B-1. The synthesized flow duration curve was adjusted to the watershed areas of each impaired stream to produce the flow duration curves for each stream as displayed in Figures B-2,
B-3, and B-4. The mean, minimum, and maximum flows estimated for each stream are shown in Table B-2.

The *E. coli* TMDLs in Section 7 were developed by converting the whole body contact category B *E. coli* criterion of 206 cfu/100 mL to pounds per day based on the flow duration curves and a conversion factor of 24,465,715 in order to generate the loading capacity in units of cfu/day. Despite the varying load, the target concentration is constant at all flow percentiles and reflects the static nature of the water quality standards. The observed data provided in Appendix A are plotted on the load duration curve graphs in Section 7 to demonstrate the magnitude of load reductions that are needed to meet the TMDLs and attain water quality standards.

Table B-1. Stream Gages Used to Develop the Synthesized Flow[21]

USGS Gage	Drainage Area (mi^2)	Period of Data	Nash-Sutcliff (%)
USGS 07188653 Big Sugar Creek near Powell, MO	141.0	10/2001- 6/2019	98
USGS 07189100 Buffalo Creek at Tiff City, MO	60.8		86
USGS 07191160 Spavinaw Creek near Maysville, AR	89.5		93
		Mean:	**92**

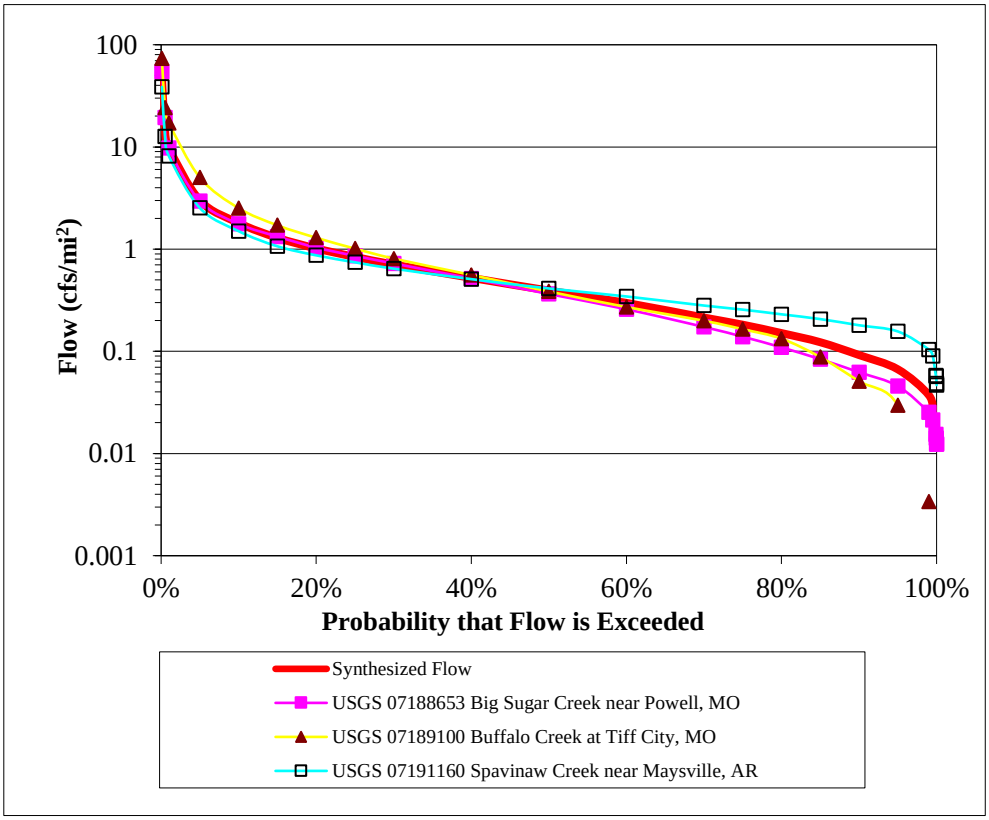

Figure B-1. Area-Based Flow Duration Curves for the Neosho EDU

Table B-2. Mean, Minimum, and Maximum Flow Estimated for Each Stream

Stream	Minimum Flow (cfs)	Mean Flow (cfs)	Maximum Flow (cfs)
North Indian Creek	0.94	46.60	5,514.23
Middle Indian Creek	0.44	21.84	2,584.80
South Indian Creek	0.95	47.28	5,594.65

[21] Flow data that were in provisional status at the time of this report were not used.

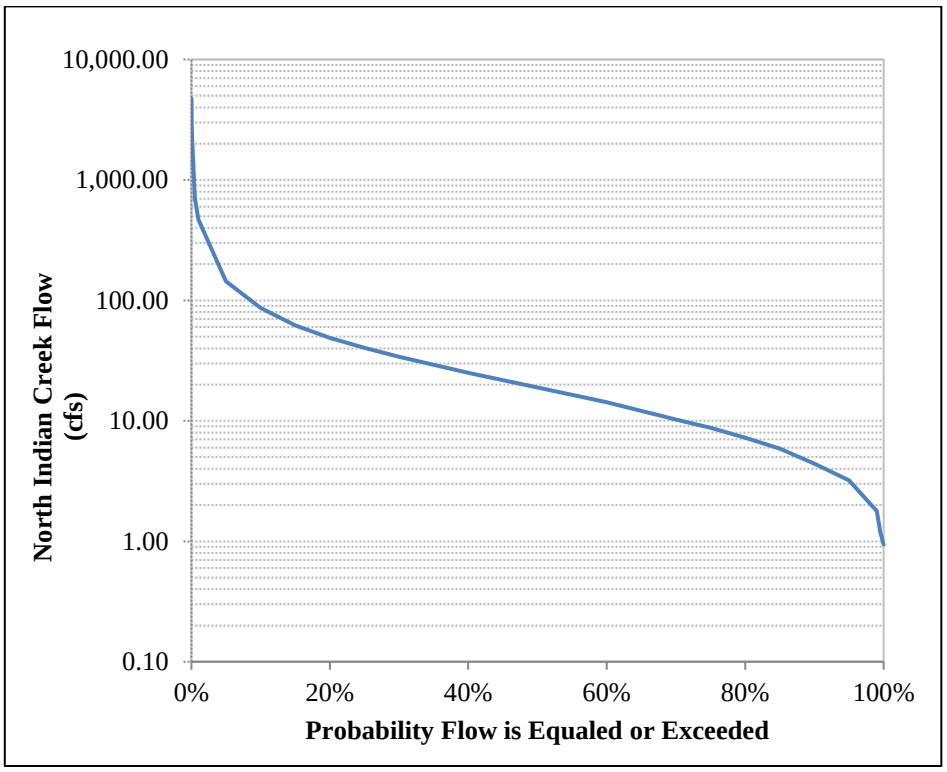

Figure B-1. North Indian Creek Flow Duration Curve

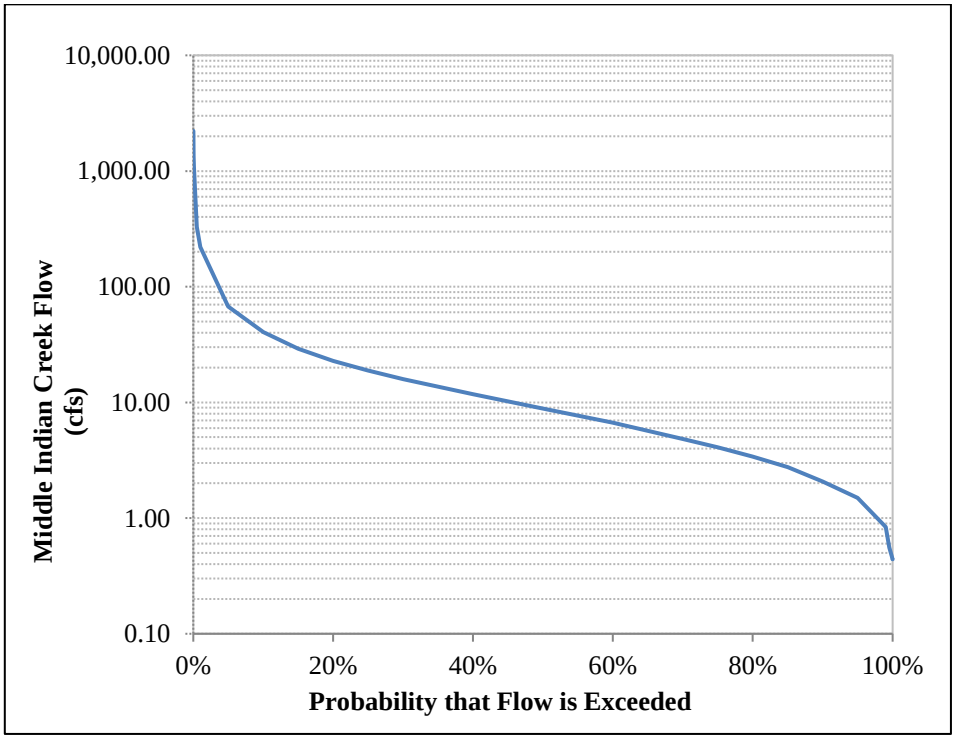

Figure B-2. Middle Indian Creek Flow Duration Curve

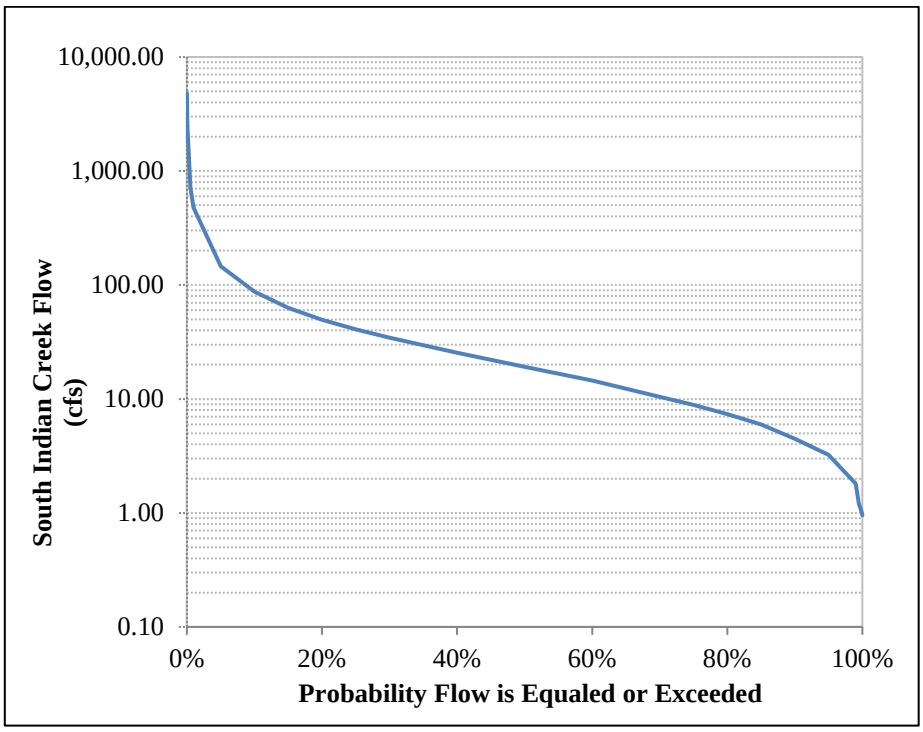

Figure B-3. South Indian Creek Flow Duration Curve